Mitigation Plan for

Obion Creek (Phase II) and Little Joe Creek, Hickman County, Kentucky

Corps ID: MVM-2009-xxx-xxx
KDOW AI# ~~xxxxx~~ 35531

Submitted: December 15, 2009

Submitted to:

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1. Mitigation Objectives

1.1 IMPACT SITE

No specific impact site is associated with this project, which is sponsored by in-lieu fees, an EPA §319(h) grant, and a Transportation Equity Act for the 21st Century (TEA-21) grant administered by the Hickman County Fiscal Court.

1.2 MITIGATION SITE

The in-lieu fee portion of this project will provide in-kind mitigation for stream losses in the Mississippi River Basin by re-establishing approximately 16,550 ft (restored length) of a third-order perennial stream (Obion Creek). The §319(h)-sponsored portion of the project will implement a riparian and wetland restoration best management practice (BMP) plan to re-establish approximately 1950 ft (restored length) of a second-order perennial stream (Little Joe Creek). The primary project goal is the re-establishment of ecological channel, floodplain, and wetland functions of Little Joe Creek and an inactive remnant Obion Creek channel. The project will continue the remediation effort initiated with the 2004 restoration of a segment of Obion Creek (Obion Creek Phase I) located immediately downstream (south/west) of the mitigation site. The mitigation site is located within the boundaries of the Kentucky State Nature Preserves Commission (KSNPC) property upstream (east) of Kentucky Highway 307 (KY-307) and the Kentucky Department of Fish and Wildlife Resources (KDFWR) property downstream (west) of KY-307 in Hickman County, Kentucky.

Inter-Agency Review Team (IRT) Review Dates

Site visit:
Concept plan approval: 16 April 2008
Construction funds approval: 13 May 2009

Functions and Services

The mitigation objectives (Table 1.1) address the functions and processes identified as most essential for supporting biologically diverse aquatic and terrestrial communities in the stream corridor while also minimizing detrimental impacts and maximizing benefits to habitat and channel morphology of upstream and downstream reaches.

Table 1.1 Mitigation Objectives

Existing Functions		Objectives
Floodplain of Proposed Obion Creek		***Proposed Obion Creek***
1. Grade control and transport and storage of fine-grained sediment (silt & sand)	The current channelized reach of Obion Creek is completely filled with sediment and debris. Sand and silt transported by Obion Creek upstream of the mitigation site are forced into the floodplain, where they deposit due to the low velocities of the shallow overland flow. These sediment deposits become concentrated where local hydraulic conditions favor their accumulation (esp. where the floodplain slopes are extremely low). In the ponded area of the site, these fine sediments can neither stay in suspension nor be transported to downstream channels, and they have accumulated across the valley bottom.	a. Maintain diverse velocity regimes within the restored channel to promote the formation of depositional features around large woody debris (LWD) habitat structures while also maintaining the transport capacity of the reach to prevent overall channel aggradation. b. Encourage more widely distributed deposition of fine-grained sediments on the floodplain.
2. Maintenance of in-channel structural habitat	Obion Creek has no existing channel within the site boundary.	Support in-channel habitat and diversity by sustaining various depths of pools and grade control structures, sinuosity, and stable LWD at or below the low-flow water level.
3. Support of streambank and floodplain vegetation	While the site is densely vegetated, perpetual ponding on the floodplain retards the propagation of many wetland species that require a dry period for seed beds to germinate. Consequently, the woody vegetation in the ponded area is dominated by bald cypress. In the downstream area of the floodplain where Little Joe and Ditch 1 drain base flow from the site, however, water levels are more variable, and woody vegetation is more diverse.	a. Maintain vegetative protection of bank and floodplain soils. b. Support diverse riparian vegetation.
4. Floodplain inundation	The valley bottom is continuously submerged throughout most of the site. The combination of impaired drainage and a persistent supply of overland flow to the ponded area prevents recession of surface water levels.	Maintain a variable floodplain inundation hydroperiod.
Little Joe Creek		***Little Joe Creek***
1. Transport & storage of fine-grained sediment (silt & sand)	This sediment size range constitutes the majority of the bedload sediment transported through the restoration reach of Little Joe Creek. It is supplied from bank erosion along Little Joe Creek and from the beds and banks of some tributaries. Due to channel incision, shear stress is frequently high enough to mobilize these sediments and transport them to downstream water bodies. Channel incision also limits their storage on the floodplain.	a. Provide grade control to maintain morphology of pools along the channel. b. Deposit fine-grained sediments on the floodplain.
2. Maintenance of in-channel structural habitat	Along Little Joe Creek, extensive shear stress caused by high banks has limited both the bed topographic stability and variability and the vertical stability. The channel is continuing to incise as multiple headcuts propagate upstream. Proportions of most pools are large-deep, and bed substrate is composed entirely of hard-pan clay. The quantity and distribution of immobile in-channel LWD is deficient throughout the reach.	Support in-channel habitat and diversity by sustaining various depths of pools and grade control structures, sinuosity, and stable LWD at or below the low-flow water level.
3. Support of streambank and floodplain vegetation	The proximity of KY-307 has reduced the quantity and diversity of riparian vegetation on the west side of the channel. The incised channel configuration and rip-rap-lined banks of Little Joe Creek do not contribute to development of diverse overbank vegetation. Channel bank vegetation is not well established where the rate of bank erosion exceeds the rate of root formation.	a. Maintain vegetative protection of bank and floodplain soils. b. Support diverse riparian vegetation.

Impact on Known Functional Impairments in the Watershed

The project is unlikely to affect the water quality of impaired stream segments upstream of the mitigation area (Section 4.7). Within the mitigation area, most of the remnant Obion Creek segment that is currently identified on the 303(d) list as non-supporting of warm water aquatic habitat (KDOW 2008; USEPA 2008) will be restored. The restored channel will replace the warm water aquatic habitat that has been lost due to the disconnection of the remnant segment from the upstream and downstream network. Potential impacts to listed segments downstream of the mitigation site have not been determined.

2. Site Selection

2.1 SELECTION FACTORS

The project site was identified by the Kentucky Department of Fish and Wildlife Resources as a potential in-lieu fee mitigation site. This site was selected for a variety of reasons, including degree of physical impact, landowner cooperation, water quality, likelihood of success, proximity to locations where fees were generated, proximity to prior restoration work within the watershed, and the potential for additional stream work within the watershed. The project site is contiguous with the Obion Creek Phase I site located immediately downstream (west) of KY-307. Channel reaches downstream from the Phase I segment offer the potential for future restoration work and would connect with the upstream portion of a KDOW Exceptional Use Water stream reach.

The following conditions and characteristics of the mitigation site make it conducive to re-establishing sustainable and self-maintaining ecological functions:

- *Floodplain size*. The entire widths of the natural floodplains of Obion Creek (2500-4000 ft) and Little Joe Creek (1500-2000 ft) are available and sufficient for conveying flood flows while supporting stream and riparian functions.
- *Substrate and sediment supply*. The supply of sand and silt to the mitigation site is high, but most of this sediment is stored on the floodplain near the channelized Obion Creek. Consequently, the supply of silt and fine sand to the proposed Obion Creek channel will be relatively low and should be less than can be conveyed by the channel. The silt and sand transported through and deposited in the low-gradient channel will also make suitable substrate for habitat.
- *Surface water hydrology*. The mitigation site is expected to continue to receive hydrologic inputs from a primarily rural/agricultural watershed with little urban development, and hydrologic conditions associated with land use are not expected to change significantly.
- *Groundwater hydrology*. The elevation and duration of soil saturation levels are expected to decrease with the drawdown of ponded surface water. The site's near-surface aquifer is perched, however, and the low-conductivity soils and local hydrology will sustain groundwater at levels sufficient to maintain wetland hydrology.
- *Water quality*. Existing water quality is expected to support biological functions (Section 4.7).
- *Soils*. Existing floodplain soils have high productivity potential and should support succession and re-establishment of riparian vegetation. The in-situ seedbed is expected to naturally germinate.

- *Landscape connectivity.* The site's existing bottomland wetlands will offer refuge areas, buffers, and green space. Limited development within the watershed offers the opportunity to enhance connectivity between landscape elements without having to accommodate adjacent competing land uses.

2.2 PROPERTY AVAILABILITY

KSNPC owns the portion of the mitigation site east of KY-307. KDFWR owns the portion of the site west of KY-307.

2.3 RARE/UNIQUE AREAS

Wildlife and Cultural Resources

Section 106 (Cultural and Historic Resources) and Section 7 (Threatened and Endangered Species) clearance/concurrence letters are provided in Appendix A. The State Historic Preservation Office has determined that the project will not affect cultural or historic resources, and the US Fish and Wildlife Service determined that no critical habitat for any federally-listed species has been designated within the Obion Creek watershed. The biological assessment/evaluation of the site found that the project will have no effect or is not likely to adversely affect any federally-listed species. The site may, however, provide potentially suitable winter habitat and/or summer roosting and foraging habitat for the federally-listed Indiana bat. Therefore, the project will comply with the recommendations outlined in the Section 7 clearance letter.

Special Use Water Resources

The entire mitigation site east of KY-307, including Murphy's Pond, is designated as an Exceptional Water wetland as part of the Obion Creek State Nature Preserve (Figure A.1 in Appendix A). Murphy's Pond is located just to the northeast (upstream) of the proposed construction area and is currently owned by Murray State University and managed by KSNPC. The pond is host to a variety of aquatic and semi-aquatic species including the cottonmouth, bird-voiced treefrog, three-toed amphiuma (state endangered), and others.

Mitigation activities are expected to support the designated special use of the pond and preserve by enhancing hydrologic functions of the site. Water surface levels in the pond are currently elevated and much less variable compared to historic levels. Following restoration of the project streams, water levels of the pond are expected to generally decrease during dry periods and become more variable during flooding. The decrease in water level during dry periods is estimated to be less than 1.5 ft based on the elevation of the surrounding floodplain surface. Personnel at Murray State University and KSNPC are aware of the potential for changes in the pond's water surface elevation.

3. Site Protection Instrument

The mitigation site east of KY-307 will remain the property of KSNPC following project completion and will be protected in accordance with 400 KAR 2:090. The portion of the site west of KY-307 (Figure A.1) lies within the Wallace tract of the Obion Creek Wildlife Management Area (WMA). This portion of the site will remain the property of KDFWR and will be protected in accordance with 301 KAR 3:010.

4. Baseline Information

4.1 LOCATION

The project site is located in Hickman County, Kentucky, 8.5 mi northeast of Clinton (Figures 1 and 2 in Appendix B). The nearest community is Beulah, located 2 mi north of the site on KY-307.

Coordinates: 36.7383°N, 88.8685°W (Obion Creek at KY-307)
36.7117°N, 88.8371°W (south/upstream boundary of mitigation site)
UTM Zone: 16

The site lies on the Dublin, Kentucky, USGS quadrangle (Figure 3) within the Mississippi River Basin (HUC 08010201). An unnamed ditch (Ditch 1) is a tributary of Little Joe Creek, which is a tributary of Obion Creek, which flows into the Mississippi River at Hickman, Kentucky.

Driving Directions

From *Memphis, TN* (about 179 mi to site):

1. Travel west to junction of I-55 N and I-40 W in Arkansas.
2. Continue on I-55 N for about 85 mi through Arkansas and Missouri.
3. Take exit 17A to merge onto I-155 E/US-412 E toward Dyersburg TN/Caruthersville. Continue on I-155 E for 47.8 mi.
4. In Tennessee, continue on Jere B Ford Memorial Hwy/Jere Ford Hwy/TN-3/S US-51 for 8.6 mi.
5. Turn left at Jere B Ford Memorial Hwy/TN-3/US-51. Continue to follow TN-3/US-51 for 12.7 mi.
6. Merge onto TN-215 W/US-51 N via the ramp to Purchase Pkwy. Continue for 1.7 mi on US-51 N into Kentucky.
7. Continue on Purchase Pkwy N for 1.1 mi.
8. Take exit 2 for KY-307 toward Fulton.
9. After 0.3 mi, turn left (south) at Fulgham Rd/KY-307. Continue to follow KY-307 for 15.5 mi to the site.

From *Frankfort, KY* (about 274 mi to site):

1. Travel south for 6.7 mi on Lawrenceburg Rd/US-127 S toward Old Harrodsburg Rd.
2. Continue on Bypass N/US-127B for another 6.7 mi.
3. Bear right at KY-513/US-127.
4. After 0.4 mi, take the ramp onto Bluegrass Pkwy W. Continue on the parkway for 58.4 mi.
5. Take exit 1B to merge onto I-65 S toward Paducah/Wendell H. Ford Western Kentucky Pkwy/Nashville/Western Kentucky Pkwy and continue for 2.2 mi to exit 91 (near Elizabethtown).
6. From this point, skip to #2 in the directions from Louisville (below).

From *Louisville, KY* (about 244 mi to site):

1. From downtown, travel south about 44 mi on I-65 S to exit 91 (near Elizabethtown).
2. Take exit 91 0.8 mi to merge onto US-31W/Western Kentucky Pkwy W toward Wendell H. Ford Western Kentucky Pkwy/Paducah.

3. Continue on Western Kentucky Pkwy W for 136 mi.
4. Take exit 1B to merge onto I-24 W toward Purchase Pkwy/Julian M. Carroll Purchase Pkwy/Paducah. Travel 16.8 mi to exit 25A.
5. Merge onto Purchase Pkwy S toward Fulton.
6. After 27.3 mi, continue on US-45 S for another 2.2 mi.
7. Take exit 22 for KY-80 toward Fancy Farm/Mayfield.
8. Turn right at W Broadway St/Fancy Farm Rd/KY-80. Continue to follow KY-80 for 8.3 mi.
9. Turn right at KY-339/KY-80/State Route 339 N and go 80 yd.
10. Turn left at KY-80/State Route 80 W. After 4.2 mi, turn left at KY-307. Continue to follow KY-307 about 4 mi to the site.

4.2 MAPS AND PHOTOGRAPHS

1. Site location map (Figure 1).
2. County road map (Figure 2).
3. USGS quadrangle map (Figure 3).
4. Aerial photography (Figure 4c).
5. NWI map (Figure C.1).
6. USDA/NRCS county soil survey (Figure 5).
7. FEMA map (Figure 6).
8. Site photographs and photo-orientation map (Figures 7–22).

4.3 CLIMATE

The annual average temperature is 58.3°F; total average rainfall is 51.81 in (Table 4.1). The growing season is 217 days (Table 4.2). All climate data were obtained from the WETS station at Mayfield, Kentucky (NRCS 2003).

Table 4.1 Regional Precipitation and Temperature Statistics
WETS Station: MAYFIELD RADIO WNGO, KY5233; Start yr. – 1971, End yr. – 2000

	Temperature (°F)			Precipitation (inches)				
					30% chance will have			
Month	Avg daily max	Avg daily min	Avg	Avg	Less than	More than	Avg # days w/ 0.1 or more	Avg total snow fall
Jan	44.6	25.8	35.2	3.69	2.54	4.57	6	3.3
Feb	51.0	29.2	40.1	4.51	2.74	5.25	6	3.4
Mar	61.2	37.5	49.4	4.89	3.45	5.81	8	0.7
Apr	71.0	45.6	58.3	4.77	3.55	5.52	7	0.0
May	78.5	55.0	66.8	5.05	3.51	6.18	7	0.0
Jun	86.1	63.6	74.8	4.06	2.38	5.22	6	0.0
Jul	89.5	67.8	78.6	4.22	2.68	4.93	5	0.0
Aug	88.5	65.9	77.2	3.22	1.37	4.27	4	0.0
Sep	82.6	58.7	70.7	3.67	2.32	4.70	5	0.0
Oct	72.7	46.7	59.7	3.65	2.40	4.24	5	0.1
Nov	59.5	38.3	48.9	5.09	3.38	5.98	7	0.1
Dec	48.9	30.0	39.4	4.99	3.09	5.91	6	0.7
Annual	—	—	—	—	46.06	54.60	—	—
Average	69.5	47.0	58.3	—	—	—	—	—
Total	—	—	—	51.81	—	—	72	8.3

Table 4.2 Growing Season Probabilities
WETS Station: MAYFIELD RADIO WNGO, KY5233; Start yr. – 1971, End yr. – 2000

Probability*		Temperature 24°F or lower	28°F or lower	32°F or lower
50 percent	Beginning and ending dates	3/22 to 11/15	3/31 to 11/4	4/13 to 10/21
	Growing season length (days)	238	217	191
70 percent	Beginning and ending dates	3/18 to 11/19	3/28 to 11/7	4/10 to 10/24
	Growing season length (days)	247	224	197

* Percent chance of the growing season occurring between the beginning and ending dates.

4.4 PHYSIOGRAPHIC REGION

The site is located in Kentucky's Mississippi Embayment (Jackson Purchase) physiographic region, which is considered the northernmost extent of the Eastern Gulf Coastal Plain region of the Southeastern US Coastal Plain (Fenneman 1917; Hupp 2000; USGS 2003). The terrain is composed mainly of gently rolling hills, broad, flat bottomlands, and terraces. Lakes, ponds, sloughs, and swamps are numerous in this low-lying plain, where local relief is typically less than 100 ft (McGrain 1983).

The region is mantled by thick loess and alluvium and is underlain by easily eroded, unconsolidated coastal plain deposits. Alluvium in the valleys typically consists of a surface deposit of clay, silt, sand, and gravel. Much of the fine-grained alluvium is presumed to be derived from the extensive erosion and re-deposition of upland sediments (Newell 2001) during the Holocene epoch, including the recent period of human land use. Cultivation of hillsides contributed to severe and extensive hillside erosion during the early part of the 20th century (Coleman 1971; Davis 1923), and sediment eroded from the uplands was deposited at the base of hill slopes, in stream beds, and on valley flats.

Channel networks throughout the region are continuing to evolve in response to the effects of extensive channelization and altered flow and sediment loads. Siltation and high turbidity are common. Most streams are deeply incised and moderately or severely entrenched, and many are actively widening. Upland streams continue to incise and appear to be major sources of silt, sand, and gravel. Bank erosion appears to be a significant source of sediment on both upland and low-gradient streams. Low-gradient streams on wide floodplains are typically aggrading, storing large amounts of sediment in the streambed and on newly formed floodplains. These channels are also re-developing sinuous planform patterns; lateral adjustment appears to be propagating upstream and downstream from constructed channel bends (Parola et al. 2005).

Bankfull geomorphic characteristics of streams in the Mississippi Embayment region may be estimated from regional curves developed by ULRF (Parola et al. 2005) for silt-bed streams with watersheds between 0.9 and 900 mi^2, sand-bed streams with watersheds between 3 and 2000 mi^2, and gravel-bed streams with watersheds between 1 and 40 mi^2 (Table 4.3). Local watershed and channel conditions, however, may cause channel bankfull flows and bankfull dimensions to differ significantly from those estimates. Therefore, the regional curves were used in conjunction with field-based geomorphic assessments of the project streams and their watersheds to estimate bankfull characteristics for the designed restoration channels (Section 6.2).

Table 4.3 Bankfull Regression Equations for Streams of the Mississippi Embayment of Kentucky

Bed Material	Regression Equation	Coefficient of Determination, R^2	Standard Error*, S_e (%)
Gravel bed	$A_{BKF} = 12.1\ DA^{0.64}$	0.93	21%
	$W_{BKF} = 12.1\ DA^{0.41}$	0.81	21%
	$D_{BKF} = 1.00\ DA^{0.23}$	0.48	28%
	$Q_{BKF} = V\ A_{BKF} = 3.5\ A_{BKF}$	—	—
Sand bed	$A_{BKF} = 16.7\ DA^{0.57}$	0.91	41%
	$W_{BKF} = 10.5\ DA^{0.34}$	0.90	26%
	$D_{BKF} = 1.60\ DA^{0.22}$	0.79	26%
	$Q_{BKF} = V\ A_{BKF} = 2.0\ A_{BKF}$	—	—
Silt bed	$A_{BKF} = 13.1\ DA^{0.63}$	0.93	31%
	$W_{BKF} = 9.47\ DA^{0.35}$	0.92	19%
	$D_{BKF} = 1.38\ DA^{0.28}$	0.83	23%
	$Q_{BKF} = V\ A_{BKF} = 1.5\ A_{BKF}$	—	—

* Transformed from the log10 domain as a percentage of the mean according to Tasker (1978).

4.5 SURROUNDING LAND USE

Much of the Mississippi Embayment physiographic region was grassland and wetland at the time it was purchased by the US. Since that time, the watersheds of Little Joe and the channelized Obion Creek have been grazed, cultivated, and presumably, logged. Aerial photographs from the 1930s confirm grazing activities within the mitigation area near the downstream limit of the site.

The Little Joe and Obion Creek watersheds currently are composed primarily of forest, range/brush, and cultivated crops (Table 4.4). The watersheds have no densely populated residential areas (Figure 4a).

Table 4.4 Land Use in Site Vicinity and Watershed

	Percent of Watershed		Percent of 1000' Buffer	
Land Cover	**Little Joe**	**Obion**	**Little Joe**	**Obion**
Forest	**38.3**	**29.51**	**60.00**	**35.42**
Deciduous Forest	36.5	27.9	59.78	32.06
Evergreen Forest	1.8	1.61	0.22	3.36
Range/Brush	**19.01**	**30.41**	**0.86**	**0.76**
Pasture/Hay	17.41	28.14	0.0	0.24
Grassland/Herbaceous	0.53	1.02	0.0	0.21
Scrub/Shrub	1.07	1.1	0.86	0.25
Barren Land	0.00	0.15	0.0	0.06
Cultivated Crops	**36.41**	**31.9**	**18.92**	**3.32**
Developed	**3.23**	**4.77**	**1.51**	**0.15**
Developed, Open Space	3.22	4.41	1.29	0.076
Developed, Low Intensity	0.01	0.36	0.22	0.075
Water	**3.05**	**3.41**	**18.71**	**60.35**
Open Water	0.73	0.58	0.0	0.120
Woody Wetland	2.03	2.83	15.27	59.36
Emergent Herbaceous Wetland	0.29	0.0	3.44	0.87

The land immediately surrounding the mitigation site (Table 4.4) is owned by KSNPC east of KY-307 and KDFWR west of KY-307. Within 1000 ft of the proposed mitigation site (Figures 4b and 4c), the majority of Little Joe Creek and Obion Creek land cover is either forest or woody wetland, as determined from the US Geological Survey's 2001 national land cover database (USGS 2008). The remaining land cover is primarily agricultural. The area has no densely populated residential areas and no major buried utility lines.

The mitigation site is expected to receive hydrologic inputs attenuated by high rates of abstraction due to infiltration and, during the growing season, evapotranspiration. Although additional areas of the watershed upstream of the site may be cultivated in the future, watershed land use is expected to remain primarily agricultural with little urban development, and hydrologic conditions associated with land use are not expected to change significantly.

4.6 CLASSIFICATION

Wetlands

Although no formal wetland delineation has been performed, wetland areas have been visually identified within the mitigation area and are delineated on the National Wetlands Inventory (NWI) (USFWS 2009) map of the area (Figure C.1 in Appendix C). The NWI identifies a cumulative area of 903 acres of wetlands (Table 4.5) within the boundaries of the mitigation site.

Table 4.5 Wetland Classification

Cowardin Classification	Total Size (acres)
PEM1F	38.46
PFO1/SS1C	23.60
PFO1/SS1F	366.36
PFO1/SS1G	20.90
PFO1A	86.05
PFO1C	162.76
PFO1F	43.72
PFO5/SS1F	47.60
PSS1/EM1F	108.31
PFO4/SS1A	5.59
Total	**903.35**

Streams

Two active channels will be impacted by the mitigation work: Little Joe Creek and Ditch 1. Little Joe Creek has been channelized upstream of and within the mitigation site. The project reach of Little Joe Creek is an F4/5 and G4/5 channel. Flow in this second-order channel is perennial.

Ditch 1 is a perennial F5/6 and G5/6 channel (Rosgen 1996). The Strahler (1957) order cannot be classified for this ditch, which is not shown as a blue line channel on topographic maps; moreover, if the ditch were a blue line channel, it would have to be classified as first order—even though it is miles from the head of the watershed that it drains—because it has no tributaries.

4.7 EXISTING SITE CONDITIONS

Landscape Setting

The project area streams are located in wide (1500-4000 ft), forested valley bottoms. The valley is bounded to the north and east by steep, forested hillsides (100-150 ft high), and to the south by broad, irregular terraces. KY-307 crosses the valley through the site. Terrestrial habitat is currently scarce in the valley bottom, much of which is submerged; the ponded areas are also inhospitable for the perpetuation of existing woody wetland species.

The Little Joe Creek riparian area consists of an asphalt roadway and its embankment on the downstream right-bank side. The downstream left-bank side of the channel is densely forested and provides refuge and buffer areas. Channel incision throughout the entire reach, however, severely limits the transfer of water, sediment, nutrients, and biota from the channel to the valley bottom.

Soils

No evidence of scraping or filling has been identified at the site. Agriculture has been widespread throughout the region, however, and the site may have been plowed in the past. The soils along the valley bottom (Figure 5) are classified as silt loams and sandy loams (NRCS 2008): Convent-Alder silt loams, frequently flooded (Cn); Convent-Mhoon silt loams, frequently flooded (Ct); Iuka sandy loam, occasionally flooded (Iu); and Mhoon silt loam, ponded (Mo). Each of these soils is listed as hydric in Hickman County. Runoff is low to medium, and saturated hydraulic conductivity is moderate to high, with the seasonal water table ranging from 12 in above the ground surface, to 36 in below. Slope ranges from 0-2%.

Floodplain soils are estimated to be more than 15 ft thick. Sub-surface exploration at the time of piezometer installation revealed a clayey-silt soil to depths greater than 10 ft. Small deposits of sand were observed on the surface of the floodplain near distributaries flowing from the filled, channelized reach of Obion Creek that borders the mitigation site.

Vegetation

Most of the project site is covered by herbaceous wetland vegetation and a mature stand of hardwood and softwood trees. A monoculture of bald cypress dominates the existing woody vegetation in much of the ponded area of the site. In the downstream area of the site, however, both west of KY-307 and east of KY-307 where Ditch 1 and Little Joe Creek drain the floodplain surface, water levels are more variable and woody vegetation more diverse.

Exotic invasive species predominate in two areas: (1) a right-of-way for transmission lines parallels KY-307 about 600 ft to its east, and this 125-ft-wide corridor is kept clear of trees and is vegetated primarily by reed canarygrass; and (2) throughout much of the PSS/EM1F and PEM1F wetland areas in the middle third of the site east of the remnant channel (Figure C.1), cattails are dense.

Hydrology

The hydrology of the entire mitigation site has been radically altered by channelization and its consequences. Water is supplied to the mitigation site via local precipitation and three sources of flow from Obion Creek's approximately 118-mi^2 watershed: one perennial stream (Little Joe Creek); multiple small floodplain distributaries; and groundwater from valley alluvium. Drainage of water from the site to downstream channels, however, has been obstructed by a valley plug and beaver dams, and most of the valley bottom has been submerged by shallow, ponded water for at least 16 years (Aerial photo 1993; Field observations 2000-2002).

Historical Regional Hydrology

Prior to Euro-American settlement of the Mississippi Embayment, the region's bottomlands were likely composed of wetlands and forests with sparse grasslands, beaver dam complexes, and low-gradient, deep channels meandering, sometimes tortuously, through the broad, flat valleys. In the nineteenth century, when agricultural practices similar to those employed in other parts of the Midwest (Happ et al. 1940; Potter 1955; Trimble 1981) and eastern US (Costa 1975; Jacobson and Coleman 1986; Wolman 1967) were introduced to Kentucky's Mississippi Embayment, changes in land-use significantly modified the hydrology of the region. Intensive cultivation without soil conservation measures eroded fine sediments from vast areas of ridge tops, hillsides, and gullies (Davis 1923: 39-45). These sediments accumulated on the valley bottoms and in the low-gradient, alluvial channels that had a low sediment transport capacity. The frequency and duration of flooding of these sinuous channels, which supported extensive wetlands and may have already been clogged with debris, may have increased. Obion Creek and Bayou de Chien were reportedly "sluggish" and "almost filled with logs, brush, and roots," with a substrate of mud 2-4 ft thick in 1890 (Woolman 1892:272-3).

To reduce the frequency of bottomland flooding and to drain wetlands for agriculture, stream channelization—including channel relocation, straightening, and enlargement—was implemented by landowners in many areas of Kentucky in the nineteenth century (Owen 1857:26; US Census 1932). While the effectiveness of these early efforts was limited by technology and a lack of coordination within drainage basins, the eventual establishment of county drainage districts by Kentucky's Drainage and Reclamation Act of 1912 and the production of heavy earthmoving equipment revolutionized channelization practices (Beauchamp 1987; US Census 1932). Large-scale channelization projects were carried out throughout western Kentucky for much of the twentieth century (Speer et al. 1965). Some portion of nearly all of the major streams and many smaller streams were channelized during this period, as extensive wetlands and barrens were converted to cropland and pasture, and long reaches of the region's sinuous channels were filled or converted to remnants, inactive and/or disconnected from the channelized segments that bypassed them (KSWCC 1982; Parola et al. 2005; Woods et al. 2002).

Channelization led to severe channel incision in most tributaries, which mobilized the loess, sand, and gravel that compose the surrounding hills (Parola et al. 2005). In main stem channels, the channel bed aggraded in many locations, and bank failure increased the supply of trees and debris (drift), which accumulated in the channel. In some channels, valley plugs resembling low-gradient alluvial fans (Happ 1975) developed: deposits completely blocked the channel, resulting in channel infill and a splay of sediment on the floodplain. Straightened channels were maintained by snagging and clearing, but aggradation and drift accumulation have continued to re-fill segments of them (Hupp 1992).

Channelized Obion Creek

Much of the Obion Creek watershed, from its headwaters to its mouth at the Mississippi River, has been channelized. An approximately 25-mi segment of the main stem, however, was left largely unchannelized between the Mississippi River bluffs and Bugg Road approximately 3.5 mi downstream of the mitigation site at a watershed area of about 140 mi^2 (Parola et al. 2008). Following channelization of more than 10 mi of Obion Creek and its tributaries upstream of Bugg Road, two valley plugs formed in the vicinity of the mitigation site. One plug formed near Bugg Road, where a channelized gravel-bed Obion Creek segment conjoins a generally unmodified meandering silt-bed segment. This Bugg Road valley plug was initiated when debris and sediment accumulated in the channel a few hundred feet upstream of that transition point.

Sometime after 1936, the KY-307 crossing of the channelized Obion Creek was replaced. The replacement bridge is now the middle structure of the three KY-307 crossings in the valley (Figure 23). Although the replacement bridge spanned the channel, the combination of the approximately 45-degree alignment of the channel and pile-group piers ensured that large woody debris would collect on the piers. After this bridge was built, the downstream channel received almost no LWD from upstream of KY-307, but it continued to fill with sediment and woody debris from tributaries that confluence downstream of KY-307. Hundreds of small distributaries eroded in the floodplain of the blocked channel, but they became defunct as the plug lengthened upstream and they no longer received flow. The Bugg Road valley plug is now composed primarily of sediment with some small debris, and it extends several thousand feet upstream, almost reaching the western side of the KY-307 crossing.

East/upstream of this crossing, LWD accumulated on the replacement bridge's piers and blocked most of the bridge opening. A massive debris jam developed, extending approximately 1.5 mi upstream in the channelized Obion Creek segment on the western border of the KNSPC property (Figure 23). When sediment and debris accumulated in this segment, the second of the two valley plugs formed ("KY-307 valley plug"). This plugged channel segment has been dredged and had debris removed at least twice since 1970, but the debris jam and valley plug re-formed both times. Near the downstream end of the mitigation site, silt and sand have covered the surface of the plug, and trees are growing on it. Fresh splay deposits at the upstream end of the KY-307 valley plug indicate that it is continuing to lengthen. Upstream of the plug, flow in the channelized Obion Creek is in backwater for approximately 1 mi, and sand and silt have accumulated to elevations above the surrounding floodplain elevation.

The blocked segment of Obion Creek is no longer capable of conveying base flow. It now acts as a drainage divide, and as in the downstream plug, hundreds of small, temporary distributaries have formed in the floodplain to its east and west along most of its length. Thus, the total flow from the contributing drainage area to the mitigation site is now less than that of the 118-mi^2 watershed, but the quantity of the flow being diverted to the west of the blocked segment cannot be reliably measured. This quantity also changes as beavers and debris blockages change the configuration of the distributaries, most of which are already defunct, and as the valley plug continues to lengthen upstream.

Flow discharged to the west of the blocked segment is conveyed to the west side of KY-307 through a bridge that crosses Cypress/Brush Creek on the southwest side of the valley (Figure 23). The large central span and large piers of this south bridge suggest that it, rather than the crossing of the channelized Obion, was intended to be the main crossing structure in the valley. Flow through this structure confluences with the Phase I restored section of Obion Creek several hundred feet west of KY-307.

Floodplain of Proposed Obion Creek

Low flow that is discharged to the east from the blocked Obion segment is conveyed through the distributaries to the mitigation site's ponded area. Sand and silt are deposited in and splayed on both sides of these small channels, whose formation also has prompted beavers to build dams on the floodplain, deepening the ponded water. Given the beaver-dam-regulated discharge from the ponded area and the persistent supply of surface water flow from upstream, the seasonal depth of the ponded surface water remains relatively constant.

During floods, a small bridge on the north end of the valley conveys flow from the floodplain of the mitigation site to the floodplain west of KY-307. Flood flows and the site's ponded water also drain to three channels near the north side of the valley: Little Joe Creek and two unnamed ditches (Ditch 1 and Ditch 2) that are tributaries of Little Joe. Flows from these channels are conveyed to the downstream Obion Phase I restored channel through the middle KY-307 crossing, which is partially blocked by the debris that instigated the valley plug. The debris blockage increases flood flow contraction through the bridge, causing a severe scour hole that wraps around the bridge's north abutment. This scour hole is the only current means of conveying base flow from the mitigation site to the downstream Phase I restored channel.

Existing Channels: Little Joe Creek & Ditch 1

The section of Little Joe Creek within the mitigation site is a perennial stream on the floodplain of the proposed Obion Creek. Water is currently supplied to the restoration reach and floodplain of Little Joe via local precipitation and two sources of flow from Little Joe's 5.19-mi^2 watershed: one perennial stream (Little Joe Creek) and groundwater from valley alluvium. At the confluence of Little Joe with Obion Creek, a tributary ditch (Ditch 1) collects flow diverted by beaver dams on the floodplain of the proposed Obion Creek. During floods, flows from the Obion Creek watershed also inundate the floodplain of Little Joe and its Ditch 1 and 2 tributaries, and all three of those channels become backwatered. Between rain-driven runoff events, the primary source of water for Little Joe Creek is groundwater.

Several beaver dams were removed from the restoration reach of Little Joe Creek shortly after the completion of the Phase I restoration in 2004. The loss of these grade controls facilitated the propagation of a headcut up Little Joe Creek and up nearly 600 ft up a defunct, filled, straight-line ditch (Ditch 1) that used to connect a short remnant channel segment to Little Joe Creek. The headcut removed sediment from the filled ditch, exposing beverage cans with detachable pull tabs. The age of these artifacts indicates that the ditch had filled with more than 4 ft of sediment over an estimated 30-40 years prior to its recent re-exposure. The advancement of the headcut further upstream in Ditch 1 has been retarded by an active beaver dam that crosses the head of the ditch where it intersects the short remnant channel segment. The dam spans approximately 2000 ft of the floodplain.

Just beyond the upstream boundary of the mitigation site, another unnamed ditch (Ditch 2) on the former Obion Creek floodplain confluences with Little Joe. Ditch 2 lies between the mitigation site and the cultivated field to the north. The ditch drains several acres of local runoff from the field; during flood events, flow from the mitigation site also may be drained by this ditch to the Little Joe channel. Sand bags and flood control gates stored on the bank indicate that flow into and through the ditch is regulated by the landowner.

The site has no other channels. A remnant Obion Creek channel has been identified in historical documents and photographs and through field reconnaissance. While the submerged contours of the remnant channel are distinguishable along much of the length of the site in the ponded area, the processes that originally maintained it are no longer active. The remnant was disconnected from the upstream and downstream network by the channelization of Obion Creek, which included filling of the original channel where it intersected the channelized section, presumably to prevent its reconnection during floods and to allow access to the land between the channelized Obion Creek and the remnant channel. The remnant is submerged and no longer conveys flow, and segments of it have been partially filled by loose, fine-grained sediment that has settled from the ponded water.

Groundwater Monitoring

While drainage efforts in the region relied primarily on construction of open channels, tiles were also installed in some areas. No evidence of tiling, however, has been identified on the site.

A total of four piezometers have been installed along the length of the valley within the mitigation site and upstream of the site where a segment of the remnant Obion Creek channel is frequently unsubmerged. Each piezometer in the floodplain is paralleled by a staff gage within the contours of the remnant channel to monitor surface water level fluctuations. Pressure transducers are being used to monitor the water elevations in all of these piezometers to quantify the level of interaction between the valley groundwater and the surface water above the remnant.

Water Quality

Obion Creek water chemistry was measured downstream of KY-307 by KSNPC on 9 May 2000. With the exception of dissolved oxygen (DO), measured water quality parameters are adequate to support aquatic life (Table 4.6). DO is expected to improve following the completion of the restoration.

Within the Obion Creek watershed, 9 stream segments (Table 4.7) are currently identified as impaired on the 303(d) list (KDOW 2008).

Table 4.6 Water Chemistry Data

Parameter	Value
Dissolved oxygen	5.4
pH	6.7
Specific conductance (µS/cm)	135.4
Temperature (C)	20.3
Percent saturation	60.5

Table 4.7 CWA Section 303(d) Impaired Water Bodies, HUC 08010201, Obion Creek Watershed (KDOW 2008; USEPA 2008)*

Location Relative to Mitig Site	Waterbody & Segment	Total Size (mi)	Waterbody ID	HUC12	County	Assess-ment Category	Use	Impairment	Suspected Source(s)
Downstream	Obion Cr 0.0 to 16.5	16.5	KY499767_01	080102010507	Fulton	5-NS	WAH	Copper	Source unknown
								Iron	Source unknown
								Sedimentation/ siltation	Non-irrigated crop production; loss of riparian habitat; impacts from hydrostructure flow regulation/ modification; channelization
							PCR	Escherichia coli	Agriculture
Unmapped	Little Cypress Cr 0.0 to 3.6	3.6	KY496697_01		Hickman	5-PS	WAH	Sedimentation/ siltation	Crop production (crop land or dry land), agriculture, non-irrigated crop production, channelization
Downstream & Adjacent	Obion Cr 40.8 to 44.2	3.4	KY499767_03	080102010505	Hickman	5-NS	WAH	Cause unknown	Channelization; source unknown
Coincident	Obion Cr 44.2 to 49.8	5.6	KY499767_04	080102010505	Hickman	5-PS	WAH	Sedimentation/ siltation	Channelization; crop production (crop land or dry land)
Upstream	Obion Cr 49.8 to 55.7	5.9	KY499767_05	080102010503	Graves	5-PS	WAH	Cause unknown	Source unknown
								Sedimentation/siltation	Agriculture
Unmapped	UT to Brush Cr 0.0 to 1.9	1.9	KY488070-2.6_01		Hickman	5-NS	WAH	Total Kjeldahl nitrogen (TKN)	Crop production (crop land or dry land)
							WAH	Phosphorus (total)	Non-irrigated crop production; crop production (crop land or dry land); agriculture; loss of riparian habitat
							WAH	Sedimentation/ siltation	Non-irrigated crop production; crop production (crop land or dry land); agriculture; loss of riparian habitat
Upstream	Opossum Cr 0.0 to 2.3	2.3	KY499959_00	080102010503	Graves	5-NS	WAH	Sedimentation/ siltation	Channelization
Upstream	Brush Cr 0.0 to 8.4	8.4	KY488070_00	080102010502	Graves	5-PS	WAH	Sedimentation/ siltation	Dredging (e.g., for navigation channels); agriculture; channelization
Upstream	Little Cypress Cr 0.0 to 2.0	2.0	KY496699_00	080102010501	Graves	5-NS	WAH	Sedimentation/ siltation	Source unknown

* Water bodies downstream of the site are included in this table only if they receive flow from the site. Tributaries of downstream waters are not included.

Stream Geomorphology

Prior to Euro-American settlement of the Mississippi Embayment, the wide VIII- and X-type valleys (Rosgen 1996) of this coastal plain region of Kentucky would have supported sinuous stream channels and bottomland hardwood wetlands. Low-gradient E- and C-type silt-/sand-bed channels would have meandered freely through the broad, flat valley bottoms. Sinuosity likely exceeded 1.5 for streams in the region, based on measurements of remnant channel reaches and stream-based property boundaries established prior to widespread stream channelization. Woody debris, tree roots, and debris jams probably played an important role in development of channel form; the low-sloped channels would have been free to avulse and cut off meander bends when obstructions formed in the channel. Avulsions also may have led to the formation of small anabranched channels.

Little Joe Creek

Little Joe Creek (Table 4.8) is currently a channelized, rip-rap lined road-side ditch. Its unnaturally straight alignment parallel to KY-307 indicates that the channel was modified over its entire length within the mitigation site. It appears to have been relocated, enlarged, and straightened, and the rip-rap appears to be regularly maintained. The planform pattern of the channel remains in a single-thread, straightened alignment.

Table 4.8 Existing Channel Characteristics

Parameter		Ditch 1	Little Joe Creek*
Drainage area	mi^2	117.8†	5.19‡
Channel length	ft	595	1151
Rosgen stream type		F5/6, G5/6	F4/5, G4/5
Strahler stream order		N/A	2
Flow regime		Perennial	Perennial
100-yr discharge	cfs	N/A§	3015
Bankfull discharge	cfs	N/A§	87
D_{50} riffle/pavement	mm	Silt and clay	Sand and small gravel
Channel slope	%	0.51	0.22
Valley slope	%	0.051	0.14
Sinuosity		1.0	1.0
Bankfull depth	ft	6**	1.5
Belt width	ft	N/A	N/A
Radius of curvature	ft	N/A	N/A
Meander wavelength	ft	N/A	N/A
Floodprone width	ft	2000-4000	35
Bankfull width	ft	21**	24
Bankfull area	ft^2	126**	35
Entrenchment ratio		>2.2	1.5
Width:Depth ratio		<12	15.8
Bank ht ratio		1.1	3.3

* Bankfull level could not be identified in either project channel. Bankfull parameters were derived from regional curves (see Section 4.4).

† Drainage area at downstream limit of Ditch 1; this includes the Little Joe watershed area.

‡ Drainage area at the upstream limit of the restoration reach.

§ Flow in Ditch 1 is not included in the USGS Kentucky Water Science Center's hydrologic data (USGS 2009).

** Top-of-bank measurement. Bankfull could not be determined from regional curves or field investigation.

The over-widened channel is incised and entrenched throughout the mitigation area. The banks, which are composed mainly of silt and clay, are steep and sparsely vegetated. Bank erosion and mass failure were observed along approximately 40% of the channel within the restoration site; some of the eroded sections are undercut. Bank heights exceed rooting depth throughout the entire reach, and the channel contains large woody debris in only a few locations; these pieces appear to have been placed by beavers.

The current channel bed profile lacks the diversity and variability generally associated with high quality habitat, with few pools or in-channel bars. The number of pools is a fraction of what would be expected in an undisturbed channel, due in part to the lack of large woody debris in the channel, the straightened alignment, and high sediment loads. The scarcity of pools, sparse in-stream and woody lower bank cover, and frequent, erosive flows create a high-disturbance environment with little refuge or cover. The substrate of the low-gradient channel is predominantly consolidated clay with occasional short sections of frequently-mobilized gravel; these sections account for less than 5% of the active channel bed. Over 90% of Little Joe Creek within the proposed mitigation site is composed of large-deep pools and a few small-deep pools. Small-shallow pools are only present where knickpoints have recently progressed upstream through the clay substrate of the channel.

Ditch 1

Ditch 1 (Table 4.8) is a recently re-exposed straight ditch that used to connect a short remnant channel segment to Little Joe Creek. The banks of the ditch, which are composed mainly of silt and clay, are steep and relatively devoid of riparian vegetation. Bank heights exceed rooting depth throughout the entire ditch, and it contains large woody debris in only a few locations; these pieces appear to have been placed by beavers.

The bed profile of the ditch is nearly flat. Sparse in-stream and woody lower bank cover and frequent, erosive flows create a high-disturbance environment with little refuge or cover. The substrate of the ditch is consolidated clay. Over 90% of Ditch 1 is composed of large-deep pools and a few small-deep pools. Small-shallow pools are only present where knickpoints recently have progressed upstream through the clay substrate of the channel.

Substrate

Channelized Obion Creek

Prior to settlement, Obion Creek and its tributaries would have carried minor amounts of fine sediment and little or no gravel (Parola et al. 2005). Modifications of the channel network and changes in land use, however, fundamentally re-organized the sediment storage system (Dietrich et al. 1982) of the watershed and changed the sediment regime. Not only did clearing and cultivation relocate fine sediment from upland surfaces to valley bottoms, but channelization of much of the Obion Creek watershed led to severe channel incision throughout the watershed and aggradation in multiple locations as sediment loads were changed from low supplies of fine-grained sediment to high supplies of both fine- and coarse-grained sediments.

The incision of upland tributaries mobilized the surrounding hills' loess and sand surficial sediments and Pliocene gravels several feet below the surface, while the incision and widening of tributary and main-stem channels into valley bottom floodplain deposits released recently accumulated silt, sand, and gravel. Consequently, a high load of gravel, sand, and silt are being transported into and through the channelized Obion Creek main stem until they reach the backwatered segment upstream of the valley plug. Bed materials grade from small-to-medium sandy gravel upstream of the KY-307 valley plug to fine sand and silt at its downstream end at KY-307. The majority of the sediment load downstream of KY-307 is fine sand and silt; coarse sand and gravel, however, are supplied by channelized tributaries and tend to be deposited near their confluences with Obion Creek.

Little Joe Creek

Pea gravel and sand are supplied to Little Joe channel reaches upstream of the mitigation site by incised headwater tributaries. In the reach that parallels KY-307 upstream of the mitigation site, no evidence of bar formation could be found, which indicates that the reach is not actively aggrading. Instead, it functions as a transport reach, conveying its load to the scour hole under and adjacent to the north KY-307 bridge at the upstream end of the restoration reach. The pea gravel and sand are stored in the scour hole.

Depending on the magnitude and frequency of high-flow events, these stored sediments are either scoured and transported onto the floodplain or are transported into and through the restoration reach. Flows that scour the stored sediments carry and deposit them on the floodplain both east and west of KY-307. These events backwater the restoration reach, however, preventing sediment transport within the channel.

When enough time elapses between scouring events for the hole to fill, the sediment load carried by smaller events may be transported through the deeply incised restoration reach and then deposited and stored in the Phase I Obion Creek channel. The restoration reach also receives some coarse- and fine-grained sediment from Ditches 1 and 2, but the supply from these ditches is negligible. Thus, the volume of sediment transported through the restoration reach to Obion Creek is minimal.

4.8 EXISTING STREAM FUNCTIONS AND SERVICES

Functional Assessment Tool(s)

The low-gradient form of the EPA Rapid Bioassessment Protocol (Barbour et al. 1999) was used to assess the existing aquatic and riparian habitat conditions of Little Joe Creek and Ditch 1. Because substrate and channel morphology are generally similar throughout each segment of channel to be restored, Little Joe and Ditch 1 were each assessed as single reaches. The habitat assessment score (Appendix D) was 85/190 (poor) for Little Joe Creek and 80/190 (poor) for Ditch 1.

Existing Functions and Services

Many of the ecological functions of the mitigation site's streams and floodplain have been impaired due to human manipulation and the channels' response to those disturbances. Therefore, the existing functions and services (described in Table 1.1) are limited compared to what they would be if the streams were to recover from the impacts of historic land-use practices and channel modifications.

4.9 RESPONSIBLE PARTIES

Applicant and Property Owner: KDFWR
Contact: Ron Brooks, Fisheries Division Director
Kentucky Department of Fish and Wildlife Resources
1 Sportsman's Ln.
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(502) 564-7109, ext. 4466

Agent: JPF
Contact: Robert B. Johnson, RC&D Coordinator
Jackson Purchase Resource Conservation and Development Fndn, Inc.
1000 Commonwealth Dr.
Mayfield, KY 42066
(270) 247-1122, ext. 5

Agent: ULRF
Contact: Arthur C. Parola, Jr., PhD
Director, Stream Institute
Dept. of Civil and Environmental Engineering
University of Louisville
Louisville, KY 40292
(502) 852-4599

Property Owner: KSNPC
Contact: Joyce Bender, Branch Manager
KY State Nature Preserves Comm.
801 Schenkel Ln.
Frankfort, KY 40601
(502) 573-2886

Lane Linnenkohl, Western Region Nature Preserves Mgr.
KY State Nature Preserves Comm.
Western Kentucky Univ.
1906 College Heights Blvd. #11075
Bowling Green, KY 42101-3576
(270) 745-7005

5. Determination of Credits

5.1 METHODOLOGY FOR MEASUREMENT OF LOSSES VERSUS GAINS

Functional assessment methods for measuring the performance of the mitigation site and calculating mitigation credits will employ four measurement tools: morphological monitoring; vegetative monitoring; hydrologic monitoring; and the modified low-gradient Rapid Bioassessment Protocol (Barbour et al. 1999) used to assess the baseline and restored habitat functions of the stream. These methods are detailed in Table 8.1.

Debit and credit ratios for stream losses and gains will be based on flow regime and RBP scores measured prior to construction (debit) and at the end of the monitoring period (credit).

6. Mitigation Work Plan

6.1 SITE PREPARATION & PROTOCOLS

ULRF and other JPF subcontractors will conduct activities associated with preparation of the site for construction, installation of necessary erosion and sediment control measures, identification of suitable construction contractors and materials, and other work necessary to begin construction. Construction contractors with the experience and equipment needed for operating under wet conditions with materials specific to the site will be selected. Traditional earthmoving techniques and operations will be used to as great an extent as practical. New techniques will also be implemented to efficiently construct a meandering channel with minimal damage to the surrounding forest.

Construction Monitoring

ULRF will provide at least weekly oversight of construction activities. Engineers will be on site to develop techniques with construction contractors, enable real-time modification of the design to minimize damage to forested areas, optimize habitat features, and facilitate contractor compliance with state laws governing nature preserves. Contractors shall leave the site free of litter. If fuels, hydraulic fluids, or oil used to maintain machinery are spilled, the fluids shall be contained and the material removed from the preserve. No burying of refuse or debris shall occur on state preserve land.

Exotic Vegetation Control

At least three preventive measures will reduce the likelihood that seeds and propagules of exotic species will be transported into newly disturbed areas in the construction zone: (1) wash-down areas will be designated for cleaning of construction equipment, and contractors will be required to pressure- and steam-wash vehicles and machinery prior to entering or leaving the site; (2) high-traffic areas currently vegetated with exotic species (primarily in the right-of-way for the power transmission lines) will be scraped to remove the existing seedbed within 6 in of the surface; and (3) exposed areas of soil will be seeded to winter wheat and mulched with clean wheat straw. Seed mixes which include non-native invasive species (e.g., crown vetch or lespedeza) will not be used.

Erosion Control

An erosion control plan for the site will be developed, and erosion control measures will be implemented and maintained prior to and during construction. Disturbance will be minimized, and exposed areas of soil will be seeded during/after construction.

Large amounts of sediment are expected to be produced during construction due to the highly saturated conditions of the site, the construction techniques to be used, and the channel length to be re-established. To ensure that construction does not increase sedimentation in downstream channels, a temporary berm will be installed approximately 100 ft downstream of the center KY-307 bridge (Figure 24) prior to construction. The berm will divert high flows and sediment away from the Phase I restored channel and into the existing Bugg Road valley plug. A low-flow culvert within the berm will allow base flow into the Phase I Obion Creek channel downstream. The berm and culvert will remain in place until construction is completed.

Soils and Substrate

All material needed for construction of the proposed channels, including substrate and large woody debris, will be obtained on site; no off-site soils will be transported to the mitigation site. Channel construction will produce approximately 8000 yd^3 of spoil material. A portion of that spoil will be used to fill Ditch 1, and spoil from excavation of the portion of Little Joe downstream of the channelized Obion segment (west of KY-307) will be deposited in the channelized segment. The remainder will be stored temporarily in the areas cleared for the pilot channels (Section 6.2). As the pilot channels evolve, the spoil will be eroded along with the bed and bank sediments that will be transported to and stored in the downstream valley plug.

Bank Stabilization

No bank stabilization will be implemented. The stabilization provided by colonizing vegetation is expected to be sufficient based on re-vegetation success in the Phase I restoration.

Equipment

Traditional earthmoving techniques and operations will be adapted for working in the site's very wet environment. Construction contractors with the experience and equipment needed for operating under wet conditions with materials specific to the site will be selected. A combination of heavy earth-moving and excavation equipment will be used. Amphibious excavators, track hoes, skid steers, bulldozers, dump trucks, and other necessary equipment are available in the region.

Strategy for Minimizing Soil Compaction

Site vehicles and construction equipment traversing the area will be directed primarily through traffic corridors. This will reduce the area of equipment compaction to specified regions. During final phases of construction operations, the high-traffic areas will be scarified to reduce compaction.

Site Access Control

The ponded, saturated conditions of the site prevent access by vehicle. All-terrain vehicles have not posed any problems at the site. If problems with unauthorized access develop, access-limiting measures will be implemented after consultation with KSNPC and KDFWR.

6.2 CONSTRUCTION PLANS

Construction is expected to include earthmoving to create sinuous channel planforms and floodplain ponds. The entire Little Joe Creek channel within the project area will be relocated and reconstructed (Figure 24). The existing channel will be at least partially filled over most or all of its length, and it will be plugged to prevent flow along the KY-307 embankment. Ditch 1 will also be at least partially filled over most of its length. A new Obion Creek channel will be constructed to connect the Phase I restored segment of Obion Creek west of KY-307 with the remnant Obion Creek channel east of KY-307 (Figure 24). The extent of the remnant Obion Creek channel to be restored within the mitigation area will be determined during the monitoring period and will depend on the extent of channel re-formed by restored flows.

Grading

Changes to existing floodplain elevations will be minimized to preserve as much of the existing forest as possible. Existing valley bottom topography will influence stream planform and longitudinal profile design: swales and depressions in the existing valley bottom will be targets for stream alignment, which will reduce the need for large volumes of earthwork.

Hydrology

Mitigation activities are not expected to change the sources of water to the site or the precipitation runoff response of the project watershed. Channel reconfiguration, however, will change both the surface and groundwater hydrology of the site (Table 6.1). While most of the current floodplain topography will be preserved, diverse hydrologic conditions will be created to support the functions of multiple aquatic habitats, including backwater channels, abandoned oxbow channels, emergent herbaceous wetlands, and forested wetlands. Hydrologic changes will also rehabilitate the ecological functions of approximately 500 acres of currently degraded wetlands on the site.

No water control structures are proposed for installation at the mitigation site.

Table 6.1 Proposed Hydrologic Changes

Design/Construction Element	Expected Hydrologic Change
Little Joe Creek	
▪ Raise channel bed elevation to reduce bank heights and entrenchment.	Slightly increase the frequency, duration, depth, and extent of floodplain inundation. Portions of the Little Joe floodplain are expected to be inundated only occasionally by flows from Little Joe; flows from Obion Creek, however, will inundate it several times per year. Allow the lower portion of the rooting zone for bank vegetation to extend into saturated soil at the low flow level of the channel to support native vegetative growth, increase sediment retention, and increase nutrient retention and processing.
▪ Increase pool frequency.	Increase the residence time of base flow.
Obion Creek	
▪ Excavate channel to connect the remnant Obion Creek segment with the Phase I restored segment. ▪ Breach the beaver dam where it coincides with the alignment of the excavated channel.	Reduce area of permanently ponded water. Re-create a variable floodplain inundation hydroperiod to allow periodic wetting and drying of floodplain wetlands, germination of the *in situ* seedbed, and propagation of bald cypress.
▪ Align the channel near existing floodplain depressions. ▪ Route restored channel through existing short remnant channel segment.	Create slackwater areas that will be prone to periodic wetting and drying. During wet periods, these backwater and off-channel areas will provide refuge for aquatic organisms away from the influence of main-channel flow velocities.
▪ Allow floodplain distributaries at the upstream end of the site to continue to supply flow from the channelized Obion Creek to the restored remnant channel.	The existing channelized segment will continue to fill with gravel and woody debris. As the blockage extends upstream over time, stream flow will continue to be redirected toward the restored remnant channel, and channel segments on both sides of the upstream channelized reach could be re-connected to improve functions of the upstream network.

Stream Planform Pattern, Longitudinal Profile, and Cross Section Geometry

Proposed dimensions for planform pattern, longitudinal profile, and cross section geometry are provided in Table 6.2. A typical proposed channel cross section of a single-thread channel reach is shown in Figure 24.

Table 6.2 Proposed Channel Characteristics

Parameter		Obion Creek	Little Joe Creek
Drainage area	mi^2	112.61*	5.19†
Channel length	ft	~18,500	1950
Rosgen stream type		E5/6,C5/6, DA5/6	E4/5, C4/5,DA4/5
Strahler stream order		3	2
Flow regime		Perennial	Perennial
100-yr discharge	cfs	19,907	3015
Bankfull discharge	cfs	430	95
D_{50} riffle/pavement	mm	Varies: silt/clay to silt/sand	Varies: small gravel to sand/silt
Channel slope	%	0.034	0.070
Valley slope	%	0.051	Crosses Obion floodplain
Sinuosity		1.94	1.71
Bankfull depth	ft	4.0	1.5
Belt width	ft	100-240	60-115
Radius of curvature	ft	60-110	40-55
Meander wavelength	ft	210-440	150-210
Floodprone width	ft	2000-4000	30
Bankfull width	ft	39	21
Bankfull area	ft^2	145	38
Entrenchment ratio		>>2.2	1.4
Width:Depth ratio		<12	14
Bank ht ratio		1	2

* Drainage area at downstream limit of restoration reach. Because the confluence of Little Joe will be relocated downstream of this point, this total does not include the Little Joe watershed.

† Drainage area at upstream limit of restoration reach.

Construction work will be divided into two construction periods. During the preliminary and first construction periods, major earth-moving work will be completed: the temporary berm and culvert will be installed (Section 6.1); short, narrow traffic corridors for equipment ingress/egress will be created; and channels will be filled and excavated. During the second construction period, woody structures will be installed, and the temporary berm and culvert will be removed.

Construction Period 1

Pilot channel construction. Two characteristics of the site will make possible the use of construction techniques that will limit the extent of floodplain and channel disturbance by heavy equipment. In the areas where equipment will be used to excavate new Little Joe and Obion Creek channels, consolidated clay is overlain by unconsolidated sand and silt. Upstream (east) of this area, the remnant Obion channel has been substantially filled by fine sediment that has settled from the ponded water, but the remnant retains some of its former contours. Therefore, with the exception of the segment of Little Joe to be excavated downstream of the channelized Obion segment west of KY-307, relatively small pilot channels will be excavated using equipment in the downstream area of the site east and west of KY-307; the remainder of the channel area and length throughout the site will be excavated only by natural channel evolution processes. ULRF expects that once the downstream Obion Creek segment has been partially excavated and the ponded water has begun to drain from the site, restored flow through the excavated and remnant channels will instigate rapid channel evolution as knickpoints migrate upstream and erode the unconsolidated channel boundaries. The evolution of the Little Joe pilot channel will be similar to that of Obion Creek. The use of this combined construction/evolution technique will restrict much of the use of earth-moving equipment to the downstream area of the site.

Cross-sectional geometry of the pilot channels will be roughly trapezoidal. The approximate pilot channel dimensions of Obion Creek and Little Joe Creek will be 4 ft wide by 5 ft deep in the center, with two outer benches that will be 4 ft wide by 3 ft deep. Rapid incision and enlargement of the pilot channels is anticipated.

Monitoring of pilot channel evolution. Following construction of the pilot channels, ULRF will monitor and document their evolution for up to 18 months. The second construction period will commence when the pilot and remnant channels have evolved to the design widths (Table 6.1). Depths of the evolved pilot channels will be approximately 6 ft for Obion Creek and will vary from 4-6 ft for Little Joe Creek; these are slightly greater than the design depths, which will be measured to the elevation of the LWD features to be installed in Construction Period 2.

Construction Period 2

Debris installation. Large woody debris and woody debris structures will be installed throughout the equipment-excavated reaches of Little Joe and Obion Creek to provide local grade control; to provide initial stability to banks, especially in bends; and to maximize available in-channel and riparian habitat (e.g., in-channel LWD and undercut banks) that otherwise would take decades to develop. The incorporation of large woody debris will be designed to prevent excessive bed or bank erosion or channel avulsion. The locations and types of woody debris structures will be determined in cooperation with the construction contractor and construction supervisor.

Monitoring of channel evolution. ULRF will continue to monitor the evolution of Little Joe and Obion creeks throughout the second construction period.

Removal of temporary berm and culvert. After all LWD structures have been placed in the channel, the temporary berm and culvert will be removed by JPF subcontractors.

6.3 PLANTING PLAN

Re-vegetation and Exotic and Undesirable Species Prevention

The need for re-vegetation will be limited because the project area is already almost entirely forested, and a concerted effort will be made to minimize removal of existing trees. Total tree clearing for the project is estimated to be approximately 6.7 acres. Except for the small traffic corridors to be cleared for equipment ingress and egress, however, most of the area to be cleared will be converted to channel. Therefore, once construction is complete, only the traffic corridors, filled sections of existing channels, and areas within 10 ft of the banks of constructed channels will constitute disturbed areas (Figure 25). These areas will be seeded to rye or winter wheat and mulched with clean wheat straw.

Planting of the site is not anticipated. The Phase I project re-vegetated naturally within six months after completion of construction, and similar results are anticipated in the Phase II site. Vegetation is dense in the surrounding vicinity of the areas to be cleared for the project, and the existing seedbank in the disturbed, highly fertile soils is expected to support rapid regeneration of many sustainable wetland species, which will also discourage colonization by non-native and/or invasive species.

6.4 SCHEDULE

The following schedule is anticipated for project construction:

Preliminary construction. Activities associated with preparation of the site for construction (e.g., installation of necessary erosion and sediment control measures) will take place from 15 January 2009 through 30 January 2009.

Construction. Stream construction will begin in January 2009.

As-built survey. Within six (6) weeks of completion of construction and berm removal, an as-built survey will be conducted for the stream.

Post-construction. Installation of any necessary site stabilization measures will commence following completion of construction and berm removal.

7. Maintenance Plan

Following completion of construction, minor maintenance may be required for such things as repair of localized bank erosion, stabilization of LWD structures, and control of invasive non-native vegetation. ULRF will be responsible for project maintenance for the first year after construction. KDFWR will be responsible for project maintenance after that time. Post-construction visits will be at least quarterly for Year 1 and twice per year during Years 2-5. KSNPC will be responsible for vegetative monitoring and maintenance for Years 1-5.

Maintenance of Constructed Features

Maintenance will include installation of any necessary modifications or enhancements to improve the stream restoration, the hydrologic conditions, and the habitat. The modifications or enhancements will be based on observed and measured restoration performance measures during the monitoring period. Recommended modifications will be reviewed and approved by both KDFWR and KSNPC prior to their implementation.

Exotic and Undesirable Species Control

Vegetative colonization of the disturbed areas of the site will be assessed semi-annually during the monitoring period to evaluate the need for preventive maintenance. Measures to ensure establishment and survival of native vegetation will be implemented as necessary, at the responsible party's discretion. In order to limit invasive species establishment, KSNPC may request re-seeding with a cover of annual rye if vegetation is not establishing to density and composition parameters similar to pre-disturbance levels. Exotic vegetation may be removed and competing vegetation may be controlled to enhance native plant survivorship and to meet project performance standards. Treatment will be conducted at the time determined to be most optimal for the effective control of the invasive species.

8. Performance Standards

8.1 MINIMUM AND PROJECT-SPECIFIC SUCCESS CRITERIA

A successfully functioning, self-sustaining restoration must have the capacity to adjust to both local changes and changes in the watershed rather than maintaining a fixed channel form. Therefore, the morphological success criteria (Table 8.1) assess indications that channel and floodplain dynamics are moving the reach-scale system toward a long-term condition where adjustments will not effect rapid, systemic change. While the restoration design will limit the potential for reach-scale changes (see Section 11.1), within-reach bed slopes, topography, and organic matter retention and distribution are expected to be dynamic. The degree and rate of change will depend on the imposed sediment load characteristics (quantity, frequency, and caliber), organic debris input characteristics (diameter, quantity, and length), and the effects of floods. Changes in the channel and floodplain morphology will be considered to be within normal parameters if they do not exceed morphologic thresholds beyond which major fluvial system changes would result. This approach will provide long-term ecological benefits at the reach scale while also minimizing detrimental impacts and maximizing benefits to upstream and downstream reaches.

The remaining criteria in Table 8.1 evaluate the extent to which riparian vegetation and structural habitat are maintained. The low-gradient RBP form to be used in evaluating habitat has been modified for use in both of this project's restored channels A modified form of the EPA Rapid Bioassessment Protocol (Barbour et al. 1999) will be used to evaluate habitat. The low-gradient form was modified to reflect the natural conditions specific to the coastal plain streams of the Mississippi Embayment physiographic region (see Table 8.2 and Appendix D).. If any of the success criteria are not met, the adaptive management plan (Section 11.2) will be applied.

8.2 EXPECTED PERFORMANCE

Obion Creek

Sediment that is transported into a channel must either be stored or transported to downstream reaches. In this mitigation site, restoration design based on transport of the existing gravel sediment supply would require construction of very large channels from the site to the confluence of Obion Creek with the Mississippi River. These channels would have to be at least as large as the existing channelized segments in the watershed, and they would have limited frequency of floodplain inundation, a low water table, high stress on the streambed, high banks vulnerable to mass failure, and dynamic substrate unsuitable for colonization in many reaches, while other reaches would be prone to aggradation and debris accumulation. On the other hand, restoration design based on reduction of sediment inputs to the restored reaches would permit construction of smaller channels capable of sustaining improved aquatic habitat and transitioning to meandering channels downstream without overloading them with coarse sediment.

Table 8.1a Stream Success Criteria: **Obion Creek**

Objectives	Success Criteria	Measurement	As-Built	Year 1	Year 2	Year 3	Year 4	Year5	Monitoring Methods
Morphology									
(Objectives 1-4)	Rosgen stream type	Cross-sectional dimensions	E5/6, C5/6, DA5/6		E5/6, C5/6, DA5/6			E5/6, C5/6, DA5/6	▪ Cross sections will be surveyed during Years 2 and 5 at 3 pools and 3 installed LWD structures. ▪ Channel morphology, habitat, and hydrology will be visually inspected at least annually and will be photo-documented annually during the vegetative dormant period.
1. Maintain diverse velocity regimes within the restored channel to promote the formation of depositional features around LWD habitat structures while also maintaining the transport capacity of the reach to prevent overall channel aggradation.	Bed degradation or aggradation	Grade control elev. changes (ft)			<1.9			<1.9	Longitudinal profile data will be collected during Years 2 and 5 and compared to the as-built profile to identify changes in the elevation of high points (grade control features) constituting either decreases or increases in excess of 1.9 ft.
	Sediment deposition	Substrate thickness (in.)	0		6-24			6-24	Longitudinal profile data collection (Years 2 and 5) will include a survey of the surface elevations of both the consolidated clay bed and the silt deposit overlying the clay bed. The difference between the two elevations at each thalweg point will be a measurement of the substrate thickness. The percentage of thalweg points meeting the thickness criterion will be a measurement of the percent surface area criterion.
		% of surface area	0		>25			>25	
Habitat									
2. Support in-channel habitat and diversity by sustaining various depths of pools and LWD structures, sinuosity, and stable LWD at or below the low-flow water level. 3. a. Maintain vegetative protection of bank and floodplain soils.	Channel habitat quality and diversity	Modified low-gradient RBP		Avg	Avg	Avg	Exc	Exc	The low-gradient RBP modified for Obion Creek will be used to assess habitat annually at a minimum of 9 sampling locations (3 pools, 3 installed LWD structures, 3 glides).
Vegetation	Re-vegetation will be monitored only in the areas disturbed by construction equipment in the downstream section of the site (Figure 25).								The volunteer flora that re-vegetate the disturbed areas will be monitored for the duration of the 5-year monitoring period. To evaluate the need for preventive maintenance, vegetation in the disturbance zones will be visually assessed at least two times per year during the growing season.
b. Support diverse riparian vegetation.	*Typha spp., Phragmites spp., Phalaris arundinacea*, and *Lythrum salicaria*		Not dominant					Not dominant	
	Exotic invasive herbaceous as indicated on Kentucky Exotic Pest Plant Council Lists 1 and 2 (KY-EPPC 2008)	% of aerial cover	40	40	40	25	20	≤10	At least one time per year during the growing season, the measured success criteria will be recorded, and the vegetation will be photographed. Monitoring plots will be established along 10-ft wide transects running parallel to the channel corridor. Plots will be 1 m^2 in size, randomly placed, and taken at a density of 10 plots per acre of disturbed area. Stations from which the vegetation will be photographed will be established near the plots in locations that optimize visibility of the vegetation.
Hydrology	A minimum of 3 bankfull flow events must be documented for the project to be released from monitoring. If 3 bkf events do not occur w/in the 5-yr monitoring period, monitoring will continue until at least 3 bkf events have been documented.								
4. Maintain a variable floodplain inundation hydroperiod.	Bankfull flow events	Cumulative # occurrences from Years 1-5			1	1-2		≥3	Annual high water marks will be documented or pressure transducers will be installed at 1 cross-section location to monitor the frequency of floodplain inundation.
	Ratio of surface water elevation to floodplain surface elevation	# days/yr ratio > 1		<150	<150	<150	<150	<150	Floodplain piezometers and in-channel staff gages will be installed in at least 3 locations (near the upstream end, the middle, and the downstream end of Obion Creek). The pressure transducers will continuously monitor the frequency and duration of in-stream water elevations, floodplain inundation, and groundwater levels, while the in-channel gages will measure surface water elevations.
Water Quality	The mitigation design for wetlands and streams will meet Kentucky Division of Water guidelines and a water quality certification will be secured if necessary.								

Table 8.1b Stream Success Criteria: **Little Joe Creek**

Objectives	Success Criteria	Measurement	As-Built	Year 1	Year 2	Year 3	Year 4	Year 5	Monitoring Methods
Morphology									
(Objectives 1-3)	Rosgen stream type	Cross-sectional dimensions	E5/6, C5/6, DA5/6		E5/6, C5/6, DA5/6			E5/6, C5/6, DA5/6	▪ Cross sections will be surveyed during Years 2 and 5 at 3 pools and 3 installed LWD structures. ▪ Channel morphology, habitat, and hydrology will be visually inspected at least annually and will be photo-documented annually during the vegetative dormant period.
1. Provide grade control to maintain morphology of pools along the channel.	Grade control	Grade control elev. changes (ft)			<1.5			<1.5	Longitudinal profile data will be collected during Years 2 and 5 and compared to the as-built profile to identify changes in the elevation of high points (grade control features) constituting headcuts in excess of 1.5 ft.
Habitat									
2. Support in-channel habitat and diversity by sustaining varying pool and dune depths, sinuosity, and stable LWD at or below the low-flow water level. 3. a. Maintain vegetative protection of bank and floodplain soils.	Channel habitat quality and diversity	Modified low-gradient RBP		Avg	Avg	Avg	Exc	Exc	The low-gradient RBP modified for Little Joe Creek will be used to assess habitat annually at a minimum of 3 sampling locations (1 pool, 1 installed LWD structure, 1 glide).
Vegetation									
b. Support diverse riparian vegetation.	Same for both channels.	See Table 8.1a.							See Table 8.1a.
Water Quality	The mitigation design will meet Kentucky Division of Water guidelines, and a water quality certification will be secured if necessary.								

Table 8.2 Proposed RBP Values Based on Modifications to Low-Gradient Form (Appendix D)

		Wadeable (>5.0 mi.^{2})	
Bioregion	**Stream Quality**	**Standard Values**	**Proposed Values**
Mississippi Valley–Interior River	Excellent	135+	128+
	Average	114-134	108-127
	Poor	0-113	0-107

5.2 DEBITS/CREDITS ANALYSIS

The impact calculation table developed by the Louisville District Corps will be used to determine the mitigation credits/debit balance. Because the restoration of Little Joe Creek is not intended to provide in-kind mitigation for stream losses, credits/debits (Table 5.1a) will be calculated separately from those for Obion Creek. Only the net adjusted mitigation units (AMUs) for the Obion Creek portion of the project will be credited as in-kind mitigation for stream losses (Table 5.1b).

Table 5.1a Estimated Stream and Wetland Credits: **Little Joe Creek**

Impacts											
Water Body	**Type**	**Quality**	**Ratio**			**Impact Type**	**Linear Ft**	**Area (acres)**		**Final Linear Adjusted Impact Units (AIU)**	
Ditch 1	Per	P	1.5			Fill	595	0.29		892.50	
Ltl Joe Crk	Per	P	1.5			Fill/relocate	1151	0.63		1726.50	
Total							**1746**	**0.92**		**2619.00**	
Mitigation											
Water Body	**Type**	**Initial Quality**	**Initial Ratio**	**Final Quality***	**Final Ratio†**	**Mitig. Type**	**Linear Ft**	**Area**	**Mitig Ratio**	**Final Linear Adjusted Mitig. Units (AMU)**	
Ltl Joe Crk	Per		0.00	E	3.00	Stream creation	1950	0.94	1	5850.00	
Wetlands‡						None		0.00		0.00	
Total							**1950**	**0.94**		**5850.00**	

Net mitigation: 3231.00 AMUs (not to be applied as mitigation for stream losses)

Table 5.1b Estimated Stream and Wetland Credits: **Proposed Obion Creek**

Impacts										
Water Body	**Type**	**Quality**	**Ratio**			**Impact Type**	**Linear Ft**	**Area (acres)**		**Final Linear Adjusted Impact Units (AIU)**
No impacts							0.00	0.00		0.00
Total							**0.00**	**0.00**		**0.00**
Mitigation										
Water Body	**Type**	**Initial Quality**	**Initial Ratio**	**Final Quality***	**Final Ratio†**	**Mitig. Type**	**Linear Ft**	**Area**	**Mitig Ratio**	**Final Linear Adjusted Mitig. Units (AMU)**
Obion Crk	Per		0.00	E	3.00	Stream creation	16,550‡	14.82	1	49,650.00
Wetlands§						None		0.00		0.00
Total							**16,550**	**14.82**		**49,650.00**

Net mitigation: 49,650.00 AMUs

* Assumes a 50-ft buffer on each side of restored perennial or intermittent streams.

† Final ratio for streams of "excellent" final quality will be 3.0 for perennial, 2.0 for intermittent, and 1.0 for ephemeral.

‡ Pre-construction estimate. The extent of the remnant Obion Creek channel to be restored within the mitigation area will be determined during the monitoring period and will depend on the extent of channel re-formed by restored flows.

§ Approximately 500 acres of wetlands on the site will be rehabilitated through restoration of site hydrology, but no wetland credits are being sought for this project at this time.

The design for Obion Creek incorporates two sediment storage zones: the existing blocked channel upstream of the KY-307 valley plug, and the remnant channel segment at the head of Ditch 1. Because the blocked channel upstream of the valley plug will be allowed to continue to accumulate LWD, gravel, and coarse sand and to splay fine sand and silt on a wide floodplain, the constructed meandering channel will be supplied only sediments that are transported beyond the splay. These sediments—mainly suspended fine sand and silt—will be sufficient to maintain an unconsolidated fine sand and silt substrate in the restored channel. Some of these fine sediments will also be stored as bank accretion within the remnant channel segment, which initially will be substantially wider than the restored channel that will flow into it. The as-built remnant segment width will vary from approximately 65-95 ft, which is much wider than the 39-ft width of the as-built Obion channel that will flow into and out of it, but the remnant segment is expected to narrow as a consequence of the accretion.

Sediment will be stored for shorter periods of time (i.e., usually less than 2 yrs) in the scour hole at the main KY-307 bridge. The scour hole is relatively wide (65 ft) and deep (15 ft) compared to the designed channel width (39 ft) and pool depth (6 ft); therefore, during all in-channel flows, fine-grained sediment transported to the scour hole will deposit in the scour hole, where it will be stored. During large flood events, similar to flows that created the scour hole, floodplain flow mixes with the much smaller channel flow to contract through the bridge opening, creating high-stress conditions that will mobilize the fine-grained sediment and transport it downstream. Although some of this sediment will be transported to the downstream channel, the quantity is anticipated to be small compared to the amount deposited on the floodplain. As flow contracts through the bridge and then expands onto the downstream floodplain, the sediment will be distributed by the floodplain flows and, as flow velocity decreases, deposited on the floodplain. Its distribution on the downstream floodplain is expected to be relatively uniform.

Upstream of the bridge, flows will also deposit sediment on the floodplain. The silt-bed channel has been designed to convey only base flow and to inundate the floodplain with only minor increases in discharge. The high exchange rate of channel and floodplain water during all flows that convey suspended silt and fine sand will allow for transfer of these sediments into the surrounding floodplain wetlands. As in the downstream section, distribution on the floodplain is expected to be relatively uniform.

Transport and deposition of fine-grained sediment within the channel will influence channel morphology locally within the restored reaches, as will the transport and deposition of LWD and placement of LWD grade-control structures. The potential for sub-reach-scale changes will depend on the channel response to the LWD. Initially, scour around structures and the deposition of fine-grained sediment upstream of structures are both likely. Both of these processes are critical for the development of high-quality habitat. Prior to the installation of the LWD structures, the excavation of the channel and evolution by erosion of the channel bed will result in a fine-grained streambed that would be consolidated and difficult—if not impossible—for some burrowing species (i.e., mussels and other crustaceans) to colonize. The placement of woody debris in the channel will create backwater areas that will be prone to deposition of fine-grained sediment over the consolidated soil. While deposition will be thinnest, more temporary, or possibly non-existent immediately downstream of woody debris structures, where channel velocity will be highest, deposition of up to 2 ft of fine-grained sediment is anticipated over at least 25% of the channel bed. The maximum thickness of the fine-grained deposit over the bed will be controlled by the supply of sediment and the elevation of the woody debris structures relative to the stream bed.

After this short-term response, significant reach-scale (i.e., 5-10 channel widths) channel change is expected to be limited due to the absence of coarse sediment and limited sand supply. Suspended silt, clay, and fine sand that are not stored in upstream reaches will be routed through and temporarily stored throughout the designed channel or permanently stored on the floodplain without causing significant reach-scale pool loss or channel aggradation above the level of LWD structures. Other sub-reach-scale changes that may occur include intermittent local bank erosion, short channel avulsion, and side channel formation around LWD obstructions; formation of new pools through locally intense scour; channel narrowing; and floodplain accretion.

Little Joe Creek

Initially, Little Joe Creek will store silt, sand and pea gravel supplied by the Little Joe Creek watershed and silt supplied by floodwaters from Obion Creek. These sediments will be stored between the LWD grade-control structures. The accumulation of sediment will continue until the bed slope between grade control structures has increased to transport the supplied load. After the bed slope between large woody debris structures has developed, it will fluctuate based on sediment supply. Most sediment supplied to the restored Little Joe channel, however, will be transported to Obion Creek over periods of one to several years.

The scour hole at the north KY-307 bridge will buffer the supply of sediment from the Little Joe Creek watershed. During events that transport sand and gravel in Little Joe Creek to KY-307, most of the sediment is expected to be deposited in the scour hole at the north bridge because of its relatively large cross-sectional area (approximately 45 ft wide and 7 ft deep). Obion Creek flood flows that contract through this bridge will then mobilize and transport these sediments to the floodplain downstream of the north bridge as floodwaters expand across the floodplain. During these types of floods, a relatively small portion of the total sand and gravel load is expected to be transported into the restored reach of Little Joe downstream of the north bridge because it will be in backwater during these events.

The potential for sub-reach-scale changes will depend on the channel response to the LWD structures. Initially, scour around structures and the deposition of fine-grained sediment upstream of structures are both likely. Both of these processes will be critical for the development of high-quality habitat. Other sub-reach-scale changes that may occur include intermittent local bank erosion, short channel avulsion, and side channel formation around LWD obstructions; formation of new pools through locally intense scour; channel narrowing; and floodplain accretion.

Obion and Little Joe Creeks

The restored channel types may change in reaches of both Obion and Little Joe creeks. Constructed single-thread E- or C-type channel reaches could change to wetland-like (DA) channels, especially in areas of debris accumulation where flow will be likely to carve new side channels on the floodplain. Conversely, reaches constructed with multiple channels (DA) may revert to single-thread reaches as side channels aggrade and atrophy. Sediment transport paths and local sorting patterns within these anabranched reaches may be highly variable as sediment inputs are routed through the separate channels. As a result, while changes in reach boundary elevations are expected to remain small (less than 1.9 ft), within-reach bed slopes, topography, and organic matter retention and distribution should be more dynamic than in the single-thread portions of the restoration. The degree and rate of change will depend on the imposed sediment load characteristics (quantity, frequency, and caliber), organic debris input characteristics (diameter, quantity, and length), and the effects of floods. In backwater areas, substrate composition may change from sandy-silt to silt and clay.

At the confluence of Little Joe with Obion, some limited local instability is anticipated. Little Joe Creek transports pea gravel and sand. During or after the monitoring period, Little Joe Creek may form at its mouth a delta that extends into Obion Creek, introducing coarse sand and gravel into Obion Creek. The delta may force lateral movement of the Obion Creek channel, and some gravel and coarse sediment may be transported and stored as a riffle in the bed of Obion Creek. These short reaches of gravel substrate will increase the diversity of in-channel habitat.

9. Monitoring Requirements

ULRF will complete monitoring, sampling, and report preparation on behalf of KDFWR; KSNPC will be responsible for vegetative monitoring. The 5-year monitoring period will commence with the first full growing season following installation of the LWD structures. Proposed permanent locations of channel monitoring are indicated in Figure 25. These locations are subject to change, however, depending on as-built conditions.

9.1 ON-SITE MONITORING METHODS

Monitoring methods are described in Tables 8.1a and b and are summarized in Table 9.1. Proposed locations of monitoring stations are indicated in Figure 25; these locations are subject to change, however, depending on as-built conditions.

Table 9.1 Summary of Monitoring

	As-built	Year 1	Year 2	Year 3	Year 4	Year 5
Obion Creek						
1. As-built survey	X					
2. Cross section surveys			X			X
3. Photographs & visual inspection		X	X	X	X	X
4. Thalweg survey			X			X
5. Bed sediment assessment			X			X
6. Habitat assessment (RBP)		X	X	X	X	X
7. Vegetative monitoring		X	X	X	X	X
8. Hydrological monitoring		X	X	X	X	X
Little Joe Creek						
1. As-built survey	X					
2. Cross section surveys			X			X
3. Photographs & visual inspection		X	X	X	X	X
4. Thalweg survey			X			X
5. Habitat assessment (RBP)		X	X	X	X	X
6. Vegetative monitoring		X	X	X	X	X
7. Hydrological monitoring		X	X	X	X	X

9.2 MONITORING REPORTS

As-Built Survey and Report

Within six (6) weeks of completion of construction, an as-built survey will be conducted for the streams. The survey will include the following data:

- The location of permanent monuments:
  - Railroad stakes will be driven into the base of trees as vertical benchmarks. At least two trees will be staked for each benchmarked location; this redundancy will reduce the potential for benchmarks to be lost due to treefall.
  - Reinforcing bar monuments will be installed at each surveyed cross section as horizontal benchmarks.
- Cross sections:
  - The downstream third of three bends, three typical straight sections, and one within 20-50 ft up- and downstream of the project reach (when appropriate and accessible). Bend cross sections will be surveyed at the location of maximum depth in the bends immediately upstream of the surveyed straight sections.
  - A minimum of 10 channel ground elevations and sufficient ground elevations to describe the valley section (where appropriate).
  - Bankfull elevation.
  - Thalweg.
  - Top of bank.
  - Any other important feature in the cross section.
- A longitudinal thalweg profile:
  - Channel slope requiring, at a minimum, surveyed points at the heads of riffles and pools and at the maximum pool depth.
  - Valley slope.
  - Constructed bankfull water surface elevation at riffles and pools.
  - Points at each established cross section and at structures will be referenced in the longitudinal profile to ensure comparability of subsequent surveys.
- Plan view map or aerial photograph that shows the locations of
  - All artificial structures (e.g., vanes, grade-control structures, bank protection, and in-channel LWD habitat structures).
  - Permanent cross sections.
  - Channel planform characteristics (bends including radius of curvature, pools, and riffles).
  - Valley characteristics (belt width, floodprone width, riparian zone).
  - Permanent monuments (with coordinates).

  The plan view or aerial photograph will also show any changes to the relocation/mitigation plan made during construction.

ULRF will submit an as-built report, including applicable construction documents, as part of the first (Year 1) annual monitoring report. The as-built report will include the following components:

- Site topographic data map showing
  - Locations and elevations of the constructed channel thalweg and bankfull elevations.
  - Locations of cross sections surveyed as part of the as-built plan.
  - Sufficient floodplain surface elevation data to depict large-scale topographic variability.
  - Location of structures and any other installations (e.g., plantings).
  - Locations of permanent benchmarks.
  - Locations of disturbed areas where vegetation will be monitored.
- A revised debit/credit table, if necessary.
- A plan outlining the short- and long-term management and maintenance of the mitigation site (Sections 7 and 10).

Annual Monitoring Reports

An annual monitoring report will be developed and provided to the Corps, KDOW, KDFWR, and KSNPC by December 31 beginning the year vegetation is first monitored and continuing for the duration of the 5-year monitoring period. Annual monitoring reports will be consistent with Corps RGL 08-03 and may be provided in digital form as a PDF file.

The annual report will provide a written summary of how the site is or is not meeting the goals and objectives of the mitigation project. It will compare and contrast the monitoring results with the baseline information and will include the following descriptions and evaluations:

1. A copy of the success criteria table (Table 8.1) with predicted and actual values.
2. An evaluation of the vegetation according to the success criteria:
   - Photographs of at least one-third of the vegetative monitoring plots.
   - Site map illustrating the surveyed locations of the vegetative monitoring photo stations and the direction in which the photos were taken.
   - Vegetative monitoring summary.
   - Analysis that compares vegetative results, goals, and success criteria (see Table 8.1).
3. An evaluation of site hydrology:
   - Description of sources and features.
   - Hydrologic monitoring summary.
   - Analysis that compares hydrologic results, goals, and success criteria.
4. Analysis of whether morphological and habitat success criteria will be met based on development of functions:
   - Representative channel photographs.
   - Comparison of as-built and current stream thalweg survey (Years 2 and 5).
   - Interpretation of annual results of the functional assessments (Table 8.1). Data forms used to evaluate points within the mitigation site will be included with the report. The data points will be depicted on a site map.
   - A description of any implemented remedial measures.
   - Recommendations for future efforts.

Release from Monitoring (Final Report)

After the fifth year of monitoring, a final monitoring report will be submitted with a request of release from further monitoring. The report will explain how the goals of the mitigation have been met and will discuss the streams' ability to be self-sustaining.

10. Long-Term Management Plan

KSNPC manages the land surrounding the mitigation site east of KY-307 and maintains signage on it. KDFWR will visit the site annually to ensure that it is protected.

11. Adaptive Management Plan

KDFWR will be the primary party responsible for adaptive management of the mitigation site in consultation with KSNPC; ULRF may also undertake remedial measures.

11.1 POTENTIAL MITIGATION CHALLENGES

Flooding. Major flood event(s) during critical construction periods and prior to vegetative stabilization of disturbed areas could cause extensive erosion, sediment deposition, or channel avulsion, which could necessitate reconstruction. Disturbance of the existing forest, however, will be very limited; the densely vegetated floodplain will dissipate flood stresses, and the existing root systems will help to stabilize channel banks. Plans for erosion control and re-vegetation are described in Sections 6.1-6.3.

Base level control. Changes in the channel or floodplain configuration immediately downstream of the restored reach could influence channel configuration in the restored reach. Of particular concern would be downstream changes leading to headward propagation of bed degradation. In sections of Obion Creek near Bugg Road, LWD has recently been removed to improve flood conveyance. The removal of these grade control features has already initiated channel incision that is likely to migrate up to the Phase I restored channel and the Phase II project reach. LWD structures installed at the downstream end of the project reach will reduce the potential for a decrease in the elevation of base level controls and subsequent bed degradation. ULRF and JPF will meet with area residents to discuss alternative measures that would preserve the grade control and habitat provided by LWD while also addressing the issues that have led the residents to alter the channel.

Beaver activity. Beaver activity is abundant on the site, and damming of the reconstructed channels could maintain ponded water on the floodplain and prevent the restoration of a variable inundation hydroperiod. The depth of the proposed channels should produce shear stresses high enough to deter in-channel construction of dams, and floodplain areas will afford the opportunity for dam/lodge construction away from the channels.

Invasive species. Because the mitigation site receives runoff from cultivated and developed areas, it is expected to receive a variety of seeds and propagules of exotic species (i.e., grasses and domestic plants) that could compete with native vegetation. Measures for control and management of exotic and undesirable species are described in Sections 6.3 and 7.

Recreational use. Activities of recreational visitors to the mitigation site that could potentially damage the site are not permitted on KSNPC property or KDFWR WMAs. KSNPC and KDFWR maintain signs at access points to identify the property as a preserve or wildlife management area. Logs will be placed within and along restored streams. Temporary access routes will be blocked with logs and wetland depressions.

11.2 REMEDIAL MEASURES

If a success criterion is not met for all or any portion of the mitigation project in any year, and/or if the success criteria are not satisfied, KDFWR will prepare an analysis of the cause(s) of failure. If the Corps or KDOW determines that remedial action is necessary, KDFWR will propose corrective measures for pre-approval after first consulting with and receiving approval from KSNPC. Actions to be taken in the event that the Corps or KDOW determines the mitigation cannot be achieved successfully at the intended site will be determined at the Corps' or KDOW's discretion in consultation with KDFWR and KSNPC.

11.3 MODIFICATION OF PERFORMANCE STANDARDS

If monitoring data show the site to be meeting performance standards in unexpected ways, KDFWR may propose revisions to performance standards for review and approval by KSNPC, the Corps, and KDOW.

12. Financial Assurances

The project is partly sponsored by a TEA-21 grant of $102,000 administered by the Hickman County Fiscal Court. The restoration of Little Joe Creek is supported by EPA §319(h) funds, while the in-lieu fee portion of the project (Obion Creek) is sponsored through the Kentucky Wetland and Stream Mitigation Fund administered by KDFWR. In-lieu-fee funds amounting to 10% of the Obion Creek restoration budget have been allocated for planning, implementation, and monitoring of any contingency procedures that may be required to achieve mitigation goals. KDFWR will allocate any necessary additional monies for implementation, monitoring, and maintenance of the Obion Creek project.

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Appendices

Appendix A Clearance/Concurrence Letters and Site Protection

Appendix B Figures

Appendix C Pre-Project Wetlands

Figure C.1 NWI mapping: locations of existing wetlands (USFWS 2009).

Appendix D Pre-Project Functional Assessment

Figure D.1 Locations of pre-project RBP assessments of Ditch 1 and Little Joe Creek. Topographic map obtained from KYDGI (2005).

Clearance/Concurrence Letters and Site Protection

A

STEVEN L. BESHEAR
GOVERNOR

TOURISM, ARTS AND HERITAGE CABINET
KENTUCKY HERITAGE COUNCIL

MARCHETA SPARROW
SECRETARY

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MARK DENNEN
EXECUTIVE DIRECTOR AND
STATE HISTORIC PRESERVATION OFFICER

October 21, 2009

Clayton Mastin
Research Project Engineer
University of Louisville Stream Institute
2301 South 3rd Street
Louisville, KY 40292

Re: Obion Creek Restoration, Hickman County, Kentucky

Dear Mr. Mastin:

Thank you for your correspondence concerning the above referenced project. The entire project area has been previously surveyed for archaeological resources. The sites present in the project area are not considered eligible for listing in the National Register of Historic Places. Therefore, in accordance with 36CFR Part 800.4(d) of the Advisory Council's revised regulations, our finding is that there are **No Historic Properties** affected for this undertaking.

Should you have any questions, feel free to contact Lori Stahlgren of my staff at (502) 564-7005, extension 151.

Sincerely,

Mark

Mark Dennen, Executive Director
Kentucky Heritage Council and
State Historic Preservation Officer

LCS/lcs

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Kentucky Ecological Services Field Office
330 West Broadway, Suite 265
Frankfort, Kentucky 40601
(502) 695-0468

July 3, 2008

Mr. Jim Lane
Kentucky Department of Fish and Wildlife Resources
#1 Sportsman's Lane
Frankfort, KY 40601

Subject: FWS #2008-B-0380, Stream Restoration and Enhancement, Obion Creek Phase II, Hickman County, Kentucky

Dear Mr. Lane:

We have reviewed the submitted information regarding the stream enhancement project on Obion Creek and an unnamed tributary to Obion Creek in Hickman County, Kentucky. According to this information, the proposed work will involve the restoration of approximately 1.5 miles of the Obion Creek and 2,000 feet of an unnamed tributary to Obion Creek.

According to our databases, one federally listed species, which may occur within Hickman County, could be affected by the proposed action. The listed species is:

Common Name	Scientific Name	Federal Status
Indiana bat	*Myotis sodalis*	endangered

We must also advise you that collection records available to the Service may not be all-inclusive. Our database is a compilation of collection records made available by various individuals and resource agencies. This information is seldom based on comprehensive surveys of all potential habitats and thus does not necessarily provide conclusive evidence that protected species are present or absent at a specific locality.

Based on the submitted package, we have insufficient information regarding any potential summer and winter habitat available on-site and any impacts that may occur as a result of the proposed action to make a determination for the Indiana bat (*Myotis sodalis*). According to Service records, summer roost and/or winter habitat for the endangered Indiana bat (*Myotis sodalis*) may exist within the proposed project site. Based on this information, the Service believes that: (1) forested areas in the vicinity of and on the project area may provide potentially suitable summer roosting and foraging habitat for the Indiana bat and (2) caves, rock shelters, and abandoned underground mines in the vicinity of and on the project area may provide potentially suitable winter hibernacula habitat for the Indiana bat.

Indiana Bat

The Indiana bat utilizes a wide array of forested habitats, including riparian forests, bottomlands, and uplands for both summer foraging and roosting habitat. Indiana bats typically roost under exfoliating bark, in cavities of dead and live trees, and in snags (i.e., dead trees or dead portions of live trees). Trees in excess of 16 inches diameter at breast height (DBH) are considered optimal for maternity colony roosts, but trees in excess of nine inches DBH appear to provide suitable maternity roosting habitat. Male Indiana bats have been observed roosting in trees as small as three inches DBH.

Prior to hibernation Indiana bats utilize the forest habitat around the hibernacula where they feed and roost until temperatures drop to a point that forces them into hibernation. This "swarming" period lasts, depending on weather conditions in a particular year, from approximately September 15 to November 15. This is a critical time for Indiana bats because they are acquiring additional fat reserves and mating prior to hibernation. Research has shown that bats exhibiting this "swarming" behavior will range up to ten miles from chosen hibernacula during this time. Indiana bats prefer limestone caves, sandstone rock shelters, and abandoned underground mines with stable temperatures of 39 to 46 degrees F and humidity above 74 percent but below saturation for hibernation.

Recommendations

Because there are concerns regarding species that relate to the project and because there is a lack of occurrence information available on these species relative to the proposed project area, the following recommendations relative to Indiana bats are suggested:

1) Based on the presence of numerous caves, rock shelters, and underground mines in Kentucky, it is reasonable to assume that other caves, rock shelters, and/or abandoned underground mines may occur within the project area. If these habitats occur, they could provide winter habitat for Indiana bats. Therefore, the Service recommends a survey of the project area for caves, rock shelters, and underground mines, the identification of any such habitats that exist on-site, and avoidance of impacts to those sites pending an analysis of their suitability as Indiana bat habitat by this office.

2) The Service also recommends that trees within the project area only be removed between October 15 and March 31 to avoid impacting summer roosting Indiana bats. However, if any Indiana bat hibernacula are identified on the project area it is recommended the applicant only remove trees between November 15 and March 31 in order to avoid impacting Indiana bat "swarming" behavior.

A written acceptance of these recommendations as project conditions is requested. If these recommendations cannot be incorporated as project conditions, the applicant should conduct a survey of the project area to determine the presence or absence of Indiana bats and to determine the likelihood of potential impacts on this species. A qualified biologist who holds the appropriate collection permits must conduct such surveys. The Service would appreciate the opportunity to review all survey results, both positive and negative. If any Indiana bats are identified, we request written notification of such occurrence(s) and further coordination and consultation.

The survey will not be necessary if sufficient site-specific information is available that shows: (1) no potentially suitable summer and/or habitat within the project area or its vicinity or (2) that the species would not be present within the project area or its vicinity because of site-specific factors. Please provide a written justification or explanation if either applies to the proposed project.

If you need additional assistance in determining if a proposed project may impact a federally listed species, we recommend that you contact us for further assistance. Thank you for the opportunity to comment on this proposed action. If you have any questions regarding the information which we have provided, please contact Jennifer Garland at (502) 695-0468 extension 115.

Sincerely,

Virgil Lee Andrews, Jr.

Virgil Lee Andrews, Jr.
Field Supervisor

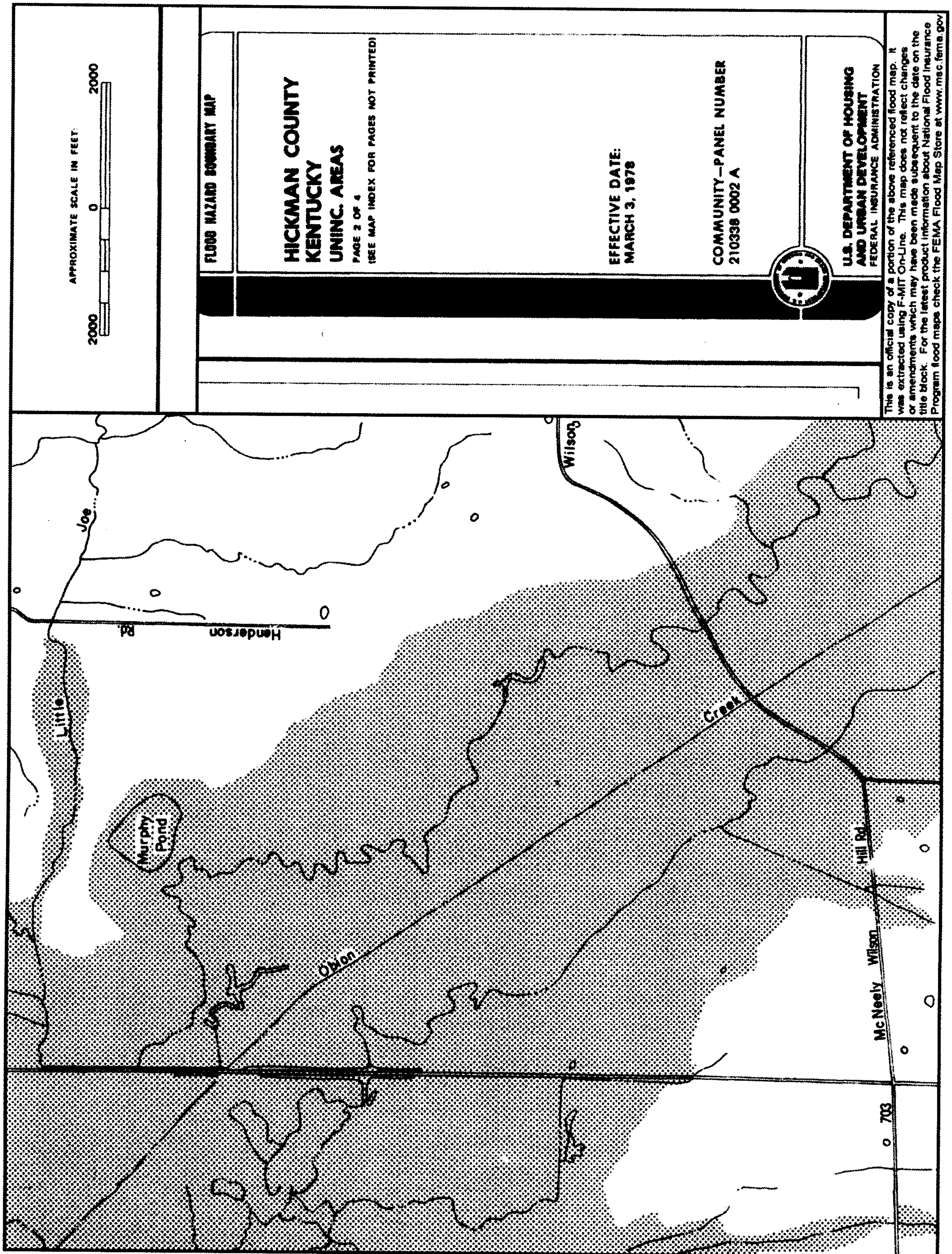

Figure 6 FEMA (2008) 1978 FIRM map of mitigation site and surrounding area.

Pre-Project Wetland Mapping | C

Pre-Project Functional Assessment | D

HABITAT ASSESSMENT FIELD DATA SHEET—LOW GRADIENT STREAMS (FRONT)

STREAM NAME Ditch 1	LOCATION See Figure D.1
STATION #________ RIVERMILE________	STREAM CLASS Perennial
LAT __________ LONG __________	RIVER BASIN Obion Creek
STORET #	AGENCY
INVESTIGATORS	
FORM COMPLETED BY CCM	DATE __8/26/2009__ TIME __10:00___ AM PM — REASON FOR SURVEY

Parameters to be evaluated in sampling reach

Habitat Parameter	Condition Category: Optimal	Suboptimal	Marginal	Poor
1. Epifaunal Substrate/ Available Cover	Greater than 50% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	30-50% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	10-30% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 10% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
SCORE 4	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2. Pool Substrate Characterization	Mixture of substrate materials, with gravel and firm sand prevalent; root mats and submerged vegetation common.	Mixture of soft sand, mud, or clay; mud may be dominant; some root mats and submerged vegetation present.	All mud or clay or sand bottom; little or no root mat; no submerged vegetation.	Hard-pan clay or bedrock; no root mat or vegetation.
SCORE 2	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
3. Pool Variability	Even mix of large-shallow, large-deep, small-shallow, small-deep pools present.	Majority of pools large-deep; very few shallow.	Shallow pools much more prevalent than deep pools.	Majority of pools small-shallow or pools absent.
SCORE 3	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
4. Sediment Deposition	Little or no enlargement of islands or point bars and less than <20% of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 20-50% of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 50-80% of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 80% of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
SCORE 14	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE 16	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

HABITAT ASSESSMENT FIELD DATA SHEET—LOW GRADIENT STREAMS (BACK)

Parameters to be evaluated broader than sampling reach

Habitat Parameter	Condition Category: Optimal	Suboptimal	Marginal	Poor
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.
SCORE 6	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
7. Channel Sinuosity	The bends in the stream increase the stream length 3 to 4 times longer than if it was in a straight line. (Note - channel braiding is considered normal in coastal plains and other low-lying areas. This parameter is not easily rated in these areas.)	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.	Channel straight; waterway has been channelized for a long distance.
SCORE 3	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
8. Bank Stability (score each bank)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
SCORE _1__ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE _1__ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
9. Vegetative Protection (score each bank) Note: determine left or right side by facing downstream.	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
SCORE _6__ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE _6__ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters: little or no riparian vegetation due to human activities.
SCORE _9__ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE _9__ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0

Total Score ____80______

HABITAT ASSESSMENT FIELD DATA SHEET—LOW GRADIENT STREAMS (FRONT)

STREAM NAME Little Joe Creek	LOCATION See Figure D.1
STATION #________ RIVERMILE________	STREAM CLASS Perennial
LAT ____________ LONG ____________	RIVER BASIN Little Joe Creek (Tributary of Obion Creek)
STOREET #	AGENCY
INVESTIGATORS	
FORM COMPLETED BY CCM	DATE __8/26/2009__ TIME __11:30___ AM PM — REASON FOR SURVEY

Parameters to be evaluated in sampling reach

Habitat Parameter	Condition Category			
	Optimal	Suboptimal	Marginal	Poor
1. Epifaunal Substrate/ Available Cover	Greater than 50% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	30-50% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	10-30% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 10% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
SCORE 6	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2. Pool Substrate Characterization	Mixture of substrate materials, with gravel and firm sand prevalent; root mats and submerged vegetation common.	Mixture of soft sand, mud, or clay; mud may be dominant; some root mats and submerged vegetation present.	All mud or clay or sand bottom; little or no root mat; no submerged vegetation.	Hard-pan clay or bedrock; no root mat or vegetation.
SCORE 2	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
3. Pool Variability	Even mix of large-shallow, large-deep, small-shallow, small-deep pools present.	Majority of pools large-deep; very few shallow.	Shallow pools much more prevalent than deep pools.	Majority of pools small-shallow or pools absent.
SCORE 11	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
4. Sediment Deposition	Little or no enlargement of islands or point bars and less than <20% of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 20-50% of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 50-80% of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 80% of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
SCORE 11	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE 13	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

HABITAT ASSESSMENT FIELD DATA SHEET—LOW GRADIENT STREAMS (BACK)

Parameters to be evaluated broader than sampling reach

Habitat Parameter	Condition Category			
	Optimal	Suboptimal	Marginal	Poor
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.
SCORE 7	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
7. Channel Sinuosity	The bends in the stream increase the stream length 3 to 4 times longer than if it was in a straight line. (Note - channel braiding is considered normal in coastal plains and other low-lying areas. This parameter is not easily rated in these areas.)	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.	Channel straight; waterway has been channelized for a long distance.
SCORE 3	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
8. Bank Stability (score each bank)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
SCORE _5__ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE _5_ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
9. Vegetative Protection (score each bank) Note: determine left or right side by facing downstream.	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
SCORE _7__ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE _5__ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters: little or no riparian vegetation due to human activities.
SCORE _9__ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE _1__ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0

Total Score ____85______

MODIFIED HABITAT ASSESSMENT FIELD DATA SHEET—LOW GRADIENT STREAMS (FRONT)

STREAM NAME Obion Creek	LOCATION	
STATION #________ RIVERMILE________	STREAM CLASS	
LAT ________ LONG ________	RIVER BASIN	
STORET #	AGENCY	
INVESTIGATORS		
FORM COMPLETED BY	DATE ________ TIME ________ AM PM	REASON FOR SURVEY

Parameters to be evaluated in sampling reach

Habitat Parameter	Condition Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
1. Epifaunal Substrate/ Available Cover	Greater than 50% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, ~~cobble~~ or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	30-50% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of new fall, but not yet prepared for colonization (may rate at high end of scale).	10-30% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 10% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2. Pool Substrate Characterization	Mixture of soft sand, mud, or clay; mud may be dominant; some root mats and submerged vegetation present.	All mud or clay or sand bottom; little or no root mat; no submerged vegetation.		Hard-pan clay or bedrock; no root mat or vegetation.
SCORE	15 14 13 12 11	10 9 8	7 6 5	4 3 2 1 0
3. Pool Variability	Even mix of large-shallow, large-deep, small-shallow, small-deep pools present.	Majority of pools large-deep; very few shallow.	Shallow pools much more prevalent than deep pools.	Majority of pools small-shallow or pools absent.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
4. Sediment Deposition	Sediment deposition of 0.5-2 ft evident on ≥25% of the active channel bed; Sediment deposition of ≥2 ft evident on <50% of the active channel bed; Tops of LWD grade control structures are completely exposed.	Sediment deposition of 0.5-2 ft evident on <25% of the active channel bed; Sediment deposition of ≥2 ft evident on >50% of the active channel bed; Tops of LWD grade control structures are completely exposed.	Sediment deposition of 0.5-2 ft evident on <25% of the active channel bed; Sediment deposition of ≥2 ft evident on >50% of the active channel bed; Moderate deposition partially covers tops of LWD structures.	Sediment deposition of 0.5-2 ft evident on <25% of the active channel bed; Sediment deposition of ≥2 ft evident on >50% of the active channel bed; Heavy deposition completely covers tops of LWD structures.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Explanation of modifications:

2. This stream should not produce the gravels and sands necessary to score >15 (optimal). Therefore, 11-15 should be considered optimal.
4. The deposition of fine-grained sediment upstream of structures is critical for the development of high-quality habitat in this channel; without it, the channel bed substrate would be consolidated and difficult for burrowing species to colonize. Therefore, sediment deposition will be promoted and controlled by placement of LWD grade control structures to create variable bed topography and a substrate favorable to mussels and other burrowing organisms.

<u>MODIFIED</u> HABITAT ASSESSMENT FIELD DATA SHEET—LOW GRADIENT STREAMS (BACK)

Parameters to be evaluated broader than sampling reach

Habitat Parameter	Condition Category: Optimal	Condition Category: Suboptimal	Condition Category: Marginal	Condition Category: Poor
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
7. Channel Sinuosity	The bends in the stream increase the stream length <u>≥1.5</u> times longer than if it was in a straight line. (Note - channel braiding is considered normal in coastal plains and other low-lying areas. This parameter is not easily rated in these areas.)	The bends in the stream increase the stream length 1 to <u>1.49</u> times longer than if it was in a straight line.		Channel straight; waterway has been channelized for a long distance.
SCORE	<u>15 14 13 12 11</u>	<u>10 9 8</u>	<u>7 6 5</u>	4 3 2 1 0
8. Bank Stability (score each bank)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
9. Vegetative Protection (score each bank) Note: determine left or right side by facing downstream.	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters: little or no riparian vegetation due to human activities.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0

Total Score __________

Explanation of modifications:

<u>7. An increase in channel length of 3-4 times over the straight-line distance is greater than what the natural sinuosity of these coastal plain streams would produce. It is about twice the 1.7 sinuosity measured downstream of the site in a 25-mi unchannelized Obion Creek segment.</u>

<u>MODIFIED</u> HABITAT ASSESSMENT FIELD DATA SHEET—LOW GRADIENT STREAMS (FRONT)

STREAM NAME Little Joe Creek	LOCATION
STATION #________ RIVERMILE________	STREAM CLASS
LAT ____________ LONG ____________	RIVER BASIN
STORET #	AGENCY
INVESTIGATORS	
FORM COMPLETED BY	DATE ________ TIME ________ AM PM / REASON FOR SURVEY

Parameters to be evaluated in sampling reach

Habitat Parameter	Condition Category: Optimal	Suboptimal	Marginal	Poor
1. Epifaunal Substrate/ Available Cover	Greater than 50% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, ~~cobble~~ or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are <u>not</u> new fall and <u>not</u> transient).	30-50% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of new fall, but not yet prepared for colonization (may rate at high end of scale).	10-30% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 10% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2. Pool Substrate Characterization	<u>Mixture of soft sand, mud, or clay; small gravel may be present; mud may be dominant; some root mats and submerged vegetation present.</u>	All mud or clay or sand bottom; little or no root mat; no submerged vegetation.		Hard-pan clay or bedrock; no root mat or vegetation.
SCORE	<u>15 14 13 12 11</u>	<u>10 9 8</u>	<u>7 6 5</u>	4 3 2 1 0
3. Pool Variability	Even mix of large-shallow, large-deep, small-shallow, small-deep pools present. <u>Ratio of maximum depth in pool to mean depth over LWD directly downstream ≥1.5.</u>	Majority of pools large-deep; very few shallow. <u>Ratio of maximum depth in pool to mean depth over LWD directly downstream 1.2 to 1.49.</u>	Shallow pools much more prevalent than deep pools. <u>Ratio of maximum depth in pool to mean depth over LWD directly downstream 1.2 to 1.49.</u>	Majority of pools small-shallow or pools absent. <u>Ratio of maximum depth in pool to mean depth over LWD directly downstream <1.2.</u>
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
4. Sediment Deposition	<u>Sediment deposition of 0.5-2 ft evident on ≥25% of the active channel bed; Sediment deposition of ≥2 ft evident on <50% of the active channel bed; Tops of LWD grade control structures are completely exposed.</u>	<u>Sediment deposition of 0.5-2 ft evident on <25% of the active channel bed; Sediment deposition of ≥2 ft evident on >50% of the active channel bed; Tops of LWD grade control structures are completely exposed.</u>	<u>Sediment deposition of 0.5-2 ft evident on <25% of the active channel bed; Sediment deposition of ≥2 ft evident on >50% of the active channel bed; Moderate deposition partially covers tops of LWD structures.</u>	<u>Sediment deposition of 0.5-2 ft evident on <25% of the active channel bed; Sediment deposition of ≥2 ft evident on >50% of the active channel bed; Heavy deposition completely covers tops of LWD structures.</u>
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Explanation of modifications:

<u>2. This stream should not produce the gravels and sands necessary to score >15 (optimal). Therefore, 11-15 should be considered optimal.</u>

<u>3. Protocol guidance suggests a difference of 1 m in depth to distinguish shallow and deep pools. In this stream, which has a drainage area of about 5.2 mi², many pools will be less than 1 m deep. Therefore, depth ratios will be used to distinguish between shallow and deep pools.</u>

<u>4. The deposition of fine-grained sediment upstream of structures is critical for the development of high-quality habitat in this channel; without it, the channel bed substrate would be consolidated and difficult for burrowing species to colonize. Therefore, sediment deposition will be promoted and controlled by placement of LWD grade control structures to create variable bed topography and a substrate favorable to mussels and other burrowing organisms.</u>

<u>MODIFIED</u> HABITAT ASSESSMENT FIELD DATA SHEET—LOW GRADIENT STREAMS (BACK)

Parameters to be evaluated broader than sampling reach

Habitat Parameter	Condition Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
7. Channel Sinuosity	The bends in the stream increase the stream length <u>≥1.5</u> times longer than if it was in a straight line. (Note - channel braiding is considered normal in coastal plains and other low-lying areas. This parameter is not easily rated in these areas.)	The bends in the stream increase the stream length 1 to <u>1.49</u> times longer than if it was in a straight line.		Channel straight; waterway has been channelized for a long distance.
SCORE	15 14 13 12 11	10 9 8	7 6 5	4 3 2 1 0
8. Bank Stability (score each bank)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
9. Vegetative Protection (score each bank) Note: determine left or right side by facing downstream.	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters: little or no riparian vegetation due to human activities.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0

Total Score __________

Explanation of modifications:

<u>7. An increase in channel length of 3-4 times over the straight-line distance is greater than what the natural sinuosity of these coastal plain streams would produce. It is about twice the 1.7 sinuosity measured downstream of the site in a 25-mi unchannelized Obion Creek segment.</u>